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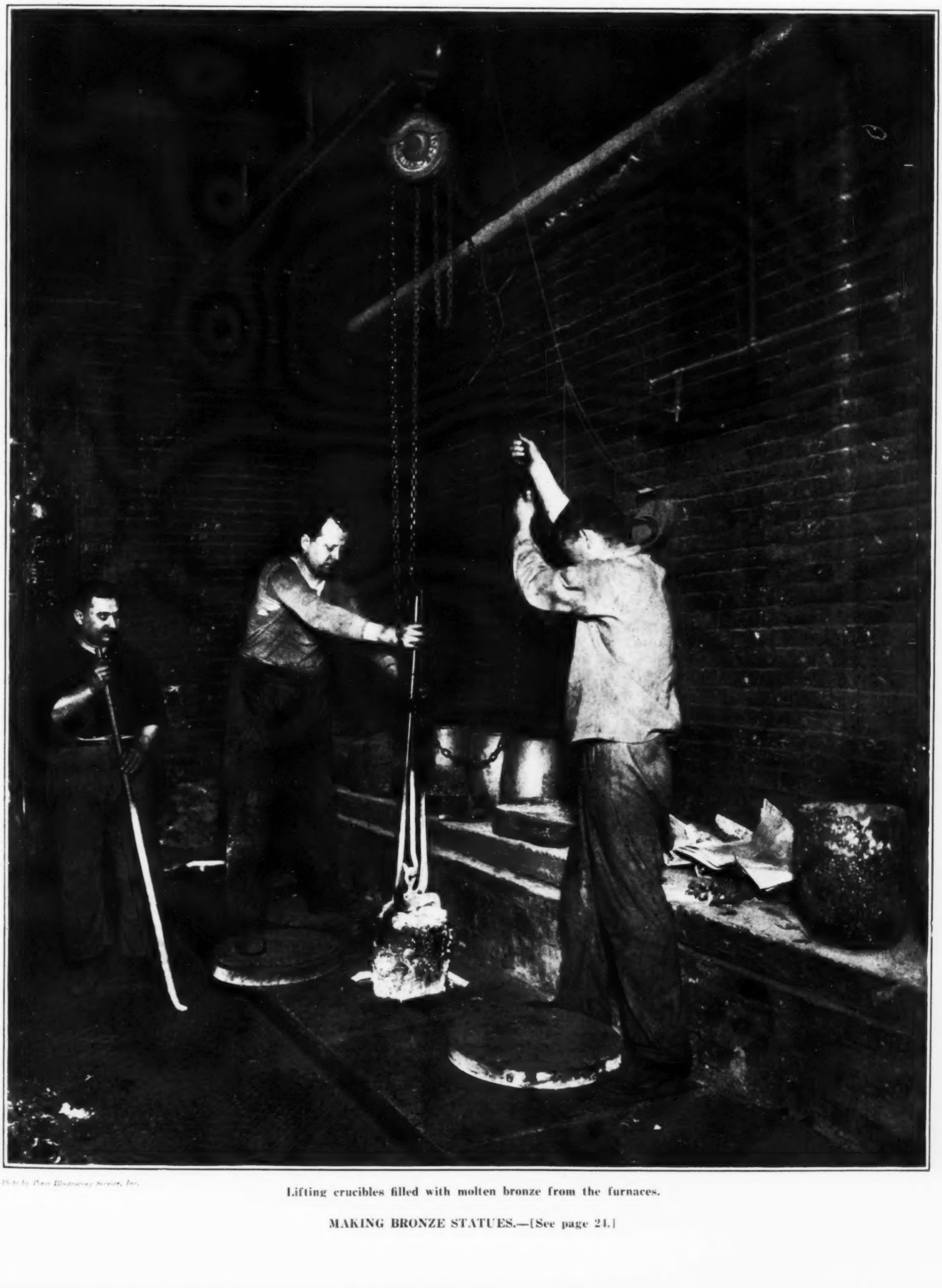


Photo by Press Illustrating Service, Inc.

Lifting crucibles filled with molten bronze from the furnaces.

MAKING BRONZE STATUES.—[See page 24.]

Systems of Payment in Factories*

A Study of Their Needs

THE methods of paying factory labor may be divided broadly into those in which the workman has the final responsibility for the execution of the processes that he uses, and those in which they are dissected and their details prescribed for him. Some work must be done partly and even largely under the first group but the bulk of work in the engineering industries can be measured in shop circumstances, and can therefore be done on methods of either group. To enumerate all the various methods of payment that have been tried would not serve the present purpose of considering the men and conditions that they respectively require. The essence of each method lies in points in which it agrees with others in its own group, and can be shown sufficiently by reference to typical examples.

DAY AND PIECE WORK.

The ordinary method of paying work that men do in their own fashion is, of course, day-work. It is not only the simplest in itself, but also is retained in most systems as the standard by which men's ratings may be compared and collective bargains made. That day-work should be done rather in the workman's fashion than according to direction may be due to convenience and custom and not to the needs of efficiency or logic; but custom is reinforced by reason in giving a workman this control when he works on piece-work. Here he is interested in his output not only morally, as a good man is on any system of payment, but also pecuniarily and, in default of a stipulation to the contrary, his contract implies that he shall be free to use his skill in what he may think the best way. The characteristic disadvantages of the system are, as is well known, that men with good piece-work rates may limit their output for fear that rates will be cut if they earn too much, and with bad rates may run short of their day-work money.

The danger of men earning less than their standard wage was faced first by Towne, whose method is most used in the modification introduced by Halsey and known as the Halsey Premium System. In this the workman is guaranteed his day-work wage, irrespective of output, but for each job a standard time is fixed, based on times previously spent in manufacturing the same or similar articles, and the workman is paid a premium for all time that he saves on this standard, reckoned at a fraction—usually a fourth to a half—of the time saved multiplied by his day-work rate, that is, of the money value of the time saved. Up to the standard time he is therefore being paid at a relatively high rate per piece; above it the price per piece falls, but as in ordinary piece-work, with which the system then becomes identical, the man's earnings may become theoretically unlimited.

While providing for the workman's fear of being left short on his week's money, this system leaves the same temptation to the employer to cut rates as does piece work. The best known attempt to meet this objection was made by Rowan, who calculated the premiums not as a fixed fraction of the money value of the time saved, but as that value multiplied by the ratio of the time saved to the time spent. In this way the workman's earnings are obviously restricted to something below twice his day-work money. The system thus reduces, on the one hand, the loss to the works on times that have been set too high and the tendency to lessen such loss by cutting them, and on the other hand the incentive to the best men to do their utmost.

TAYLOR'S SYSTEM.

While methods such as these had been under consideration and trial, and were meeting with some success, F. W. Taylor was attacking the question by assuming responsibility for the manner in which the work was done, and coupling his pecuniary incentive with the condition that the workman must follow his directions implicitly. Of his system the essentials have been adopted as the basis of numerous variants and developments, but in the classification of methods of payment his name is identified with the method of differential piece-work which he devised and usually preferred. On this method the workman has no guarantee of his day-work money, and is paid for each job according to a standard time and one of two rates—a low rate for all work that has taken more than the standard time, and a high rate for all done in or below that time. The effect is to weed out all but what Taylor called "first-class men"; and his method has often been attacked on the ground that it must necessarily deprive a large number of men of their legitimate employment. The criticism is known more widely than is his answer to it, which was that his "first-class man" is one whose physique and temperament give him natural aptitude for his job, and that the effect of restricting each employment to men who are "first-class" in it is merely to send the others to kinds of employment in which they also will be "first-class."

Of the various modifications by which it was sought to avoid Taylor's drastic rejection of men below "first-class," those introduced respectively by Gantt and Emerson may be taken as typical.

GANTT AND EMERSON SYSTEMS.

The Gantt "Task and Bonus" formula guarantees the man's day-work money, and on his attaining a given output adds to it a bonus of an agreed fraction—perhaps 30 per cent—of the money-value of the hours credited to him on the job multiplied by the ratio of his output to the standard output. The system is thus equivalent to Halsey's, except that it is used for directed work, and its bonus increases more rapidly with increase of output.

Emerson's "Efficiency Plan" is identical with Gantt's system except in the method of calculating and paying the bonus. Taking a man's efficiency to be measured by the ratio of the time spent on the job to the standard time, Emerson prepares a schedule for each works or each class of jobs, showing a fixed bonus in money per hour for each efficiency. The schedule begins with an efficiency of perhaps 67 per cent on which a very small bonus is reserved, and rises by intervals of 1 per cent, the bonus accelerating with each increase up to a large figure for about 100 per cent efficiency. The final increment for that stage and upward is perhaps 1 cent per hour for each 1 per cent of increase of efficiency. A characteristic feature of the system is that the efficiency is reckoned monthly over all jobs, thus tending not only to deter men from slacking and so reducing the monthly figure of efficiency on which bonus will be paid, but also to prevent a man from being discouraged on any individual job on which he has happened to make a bad start.

For the most efficient working each of these systems has certain essential needs that are common to all, and require no discussion here. The works' organization, for instance, must be such as to assure regular supplies; the layout and system of work must avoid needless handling and transport; material and product must be inspected at each stage, so as to avoid wasting work on imperfect pieces. But in certain essentials self-directed and directed work have different needs, most notably in the men employed and the conditions of their training.

DAY AND PIECE-WORK MEN.

The workman who, as in self-directed work, has to make the final choice of the operative details by which his job is to be done, and to some extent of the tools that he is to use, requires as wide a knowledge as possible of methods and tools, so as to give himself the best selection and enable him to make the best use of his individual manipulative skill. Such knowledge, however, is only potential efficiency; to turn it into actual output the man must also have the activity of mind by which he can use it as required, and the enterprise and energy that will lead him to do so. In a machine job, for instance, he must know the shape and angle of tool best suited to the material, the best speed and feed for the job, the right tension of his belt, and a variety of similar details; and to this knowledge he must add constant vigilance to see that the best conditions are maintained, and immediate activity in attending to any change that may occur to them, all in addition to the actual manipulations by which he does the work itself.

His foreman, again, has to possess all the workman's qualities, so that he may in need serve his men as a universal consultant, and others as well. He must be able to receive normal orders interspersed with urgent and emergency work, to choose their respective precedence so as to meet requirements that may often be conflicting, and to satisfy those departments whose work he cannot do first. He must incessantly assure the progress and clearance of work, and deal with hitches such as late or wrong delivery of material, defects of workmanship, and failure of running plant. He must, in fact, add to the technical knowledge and alert application by which he is his men's stand-by a quite considerable organizing and administrative ability. Finally, he has to possess good judgment of his men's respective capacities to guide him in allotting work, a keen scent for the multifarious forms of slackness, and a determination to discharge, irrespective of obstacles and his personal feelings, duties that have largely and constantly to be determined by his own judgment.

PRINCIPLE OF DIRECTED WORK.

This list of qualifications of men and foremen engaged on self-directed work does not form a complete statement of what is required in them, and certainly does not overstate the complexity of the abilities that they should possess. Even as it stands, however, it shows that each man's efficiency in self-directed work depends on his being efficient in a considerable number of quite different qualities. Now to find a man who possesses eminently one single quality is obviously far easier than to find one who has a number of qualities in equal eminence, and until recent years traditional practice has been to attack complete jobs—that is, jobs requiring more than one quality—with the help of men who have a minimum efficiency in each of the required qualities and, if possible, are eminent in one or two. The alternative is to split up the complex job into elements each requiring a single quality and little more. So far back as 1832 Babbage pointed out that an essential advantage of division of labor is that men can be used for pre-eminence in a single quality, instead of being required to exhibit other qualities as well, in one or more of which they are likely to be less efficient. The same observation, as Babbage afterward found out and announced, had been made in 1815 by Gioja, an Italian economist. It is this advantage that, quite independently, Taylor and his school have sought to use in the systems of directed work.

DIVISION OF LABOR.

The principle of division of labor was applied first by dividing work according to the product required. Thereafter it extended to a division according to the processes used; and in engineering this extension has involved a sharp and often arbitrary classification of men according to the processes to which they are attached and in many cases restricted. The systems of directed work extend the principle to the elementary functions and motions of which each administrative and mechanical process is made up. Thus each administrative function—routing, supplies, inspection, clearance, and the like—is undertaken by a separate person, and no function is grouped with another in one man's job unless the sum-total of it that is required in the shop is too small to occupy one's man's whole attention. The several matters that in self-directed systems engage the attention of workmen and the general foremen are similarly sub-divided; one man for speeds and feeds, another for belts, and so forth. Finally the manipulations of the workman himself are analyzed into their constituent motions, with their respective durations noted, and on some methods recorded by cinematograph to the three-thousandth of a minute. On the basis of such observations needless motions are eliminated, and fresh combinations devised where desirable; the whole analysis resulting in a bill of directions for the job, by which the single process which the workman has previously been required to perform is resolved into a definite set of elementary motions made in the combination and sequence and under the conditions that are known to be the most efficient, in much the same way as would be done by a special machine designed for a complete operation, or a university crew trained for a race. The same principle may be applied, again, as occasion arises in setting men to use the prescribed motions in other combinations and sequences, and so to perform processes or operations other than those to which they have previously been restricted.

NEEDS OF DIRECTED WORK.

The needs, therefore, of directed work are distinguished fundamentally from those of self-directed work by requiring men with single qualities instead of with many. In some respects in which their needs are similar to those of other systems they are distinguished by being felt more acutely. Directed work, for instance, tends to lead men to their utmost production, and to

*London *Times Engineering Supplement*. By an engineering correspondent.

reduce their opportunities of diminishing their application or intensity of work for the purpose or with the result of counteracting the effect of long hours. At the same time, it is more dependent than other work on men working cheerfully and with good will; and much more having been spent on each man's shop training than is spent on men engaged in self-directed work, it is at direct loss if a worker's health and efficiency become impaired. It therefore shares with other work the anxiety to adjust hours of work and intervals of rest so that men's occupation shall not be mischievous to their health; but its interest in securing this is of a far greater order of magnitude. Similarly, it feels in common with other systems the advantage of having its shops above a certain minimum size; but in so far as it weeds inefficient men out of their jobs with greater certainty and has greater facilities for finding them jobs in which they will be efficient, it is much more keenly interested in the shops being large enough to provide the necessary variety of labor. Its need for finding enough in each separate function to occupy a man's whole time, and for the volume of work that can afford its gross increase of expenses not spent directly on the product, are still more obvious reasons to the same effect.

EDUCATION FOR INDUSTRIAL WORK.

But it is in the education it requires for its men that its needs differ most radically from those of self-directed work. Directed work, though employing a larger number of men for directional purposes than self-directed work, must nevertheless find the large majority of its men engaged immediately on the product. These men have to be no less vigilant than self-directed men in detecting any disturbances of their machines, though they may not themselves have to set them right; and in producing rapidly as well as accurately they may have the same sort of mental interest as a racing man in his work. But on balance their mental occupation during working hours is less both in extent and variety than that of a self-directed worker, and the consequent relative monotony of occupation has in some way to be counteracted. At the same time the hours of work of directed men must inevitably, through the greater intensity that can be attained, become shorter than those of self-directed workers, and a considerable volume of time will be on their hands beyond what is required for inactive rest.

It is sometimes suggested that the interests of such workers would be best served by devoting this spare time to technical education. As a fact, however, most of the technical knowledge that they will need will be given them in their shop-training and in the explicit bills of directions by which each job is accompanied; and, in contrast with the unquestioned need of self-directed men for extended technical education, directed men engaged immediately on production—the large majority of those employed—require little more technical education than they get at their work but a great deal more general education, by which they may offset the relative monotony of their shop-work and take advantage of their increased leisure. What they need from such education is not so much technical knowledge as larger powers of observation and thought, wider interests, clearer judgment. These will lead to more sympathetic understanding of other men, and to habits of mind and feeling that will attach them more intelligently and closely to their associates and their community, and will give them their share in the humanities by which civilized man should be distinguished from the slave.

GRADUATED CURRICULA.

These requirements apply no less to the men, much more numerous in directed than in self-directed work, who are to be concerned in the operations of direction; but these men will require substantially more technical education than they can expect from the shops. The extent will vary with the work that they are ultimately to do; and it is particularly important that for each class a self-contained curriculum should be provided, going beyond what is needed for the grade in view only just far enough to enable the student to follow on to the next higher course, if by his disposition, abilities, and circumstances he is fit for it. This principle applies first to the extent of technical education to be given to the operative mechanic. It should be just sufficient to inspire those who are fit for direction to enter on the competition for it; and the curricula that follow on this elementary stage should be separated by relatively small intervals, so that a large number of distinct stages may be created, and definite standards set up to suit the respective abilities of all men. It is better for an industry and its workers that most men should have a station to desire which they are reasonably likely to attain than that they should be fretted constantly with disappointment and a sense of failure, such as necessarily would be almost universal if no standard of ambition was recognized except the highest. If technical curricula follow one another with just enough overlap to make them certainly continuous, the increase of general education that must be provided for the reasons already described will prompt those who are fit for later technical training to undertake it, and will supply to those who do not do so the means of using their lives to their own greatest happiness and to the utmost benefit of their family, their trade, and their country.

What Is "Hardness?"*

DEFINITE as our sense impressions are of hardness and softness within a certain range, it remans a fact that science has not yet succeeded in formulating a satisfactory definition of the term "hardness." Still less successful have been the efforts made to devise means for measuring it in terms which are other than arbitrary. As to what hardness is and what causes it, we may be said to be in profound ignorance. According to Dr. Unwin, hardness is the resistance a material opposes to penetration by another body. Dr. A. E. H. Tutton defines it as the resistance offered by a smooth surface of a solid substance to abrasion by a sharp fragment of another substance of slightly greater hardness. Sir Robert Hadfield conceives it to be simply "resistance to deformation," and holds that to measure it in a metal one has only to measure the yield point. In practice "hardness" is measured by means of various forms of testing devices, of which the Brinnel indentation instrument, the scleroscope rebound instrument, and Prof. Turner's scratch test instrument are typical. The Brinnel method is in wide practical workshop use, and is undoubtedly a valuable aid in many processes, particularly at the present moment. A fourth conception of "hardness" should also be noted. According to many, we might almost say to most, practical engineers hardness in a metal is identical with its power of resisting wear. That hardened material resists wear better than material not hardened is very generally true, and its truth is exemplified in the practice of case-hardening, and of hardening and tempering tool steel. Indeed, it may be said that in almost every case the engineer desires hardness in certain parts of his machines only because he wants those parts to have an enhanced resistance to wear. This aspect of hardness is the really important one from the practical point of view. Direct tests on the resistance of a metal to wear are, however, very difficult to carry out under workshop conditions, and absorb much time even in the hands of a skilled experimenter. It is, therefore, of great importance to determine first whether the simpler appliances used in the Brinnel, scleroscope, or scratch tests do give us reasonable and consistent measurements of hardness, and, secondly, whether the hardness so measured may really be identified with resistance to wear.

It may fairly accurately be said that the Brinnel indentation test corresponds with Dr. Unwin's definition of hardness, Prof. Turner's scratch test instrument with Dr. Tutton's definition, and—although this point is not immediately obvious—the scleroscope with Sir Robert Hadfield's conception of hardness. Little reflection is required to show that the three definitions can scarcely be consistent among themselves and that the three instruments can hardly be held to measure one, and only one, property of metals, and that one the same in all three cases. The Brinnel test determines the "hardness" by observing the indentation produced in a specimen when a sphere commonly 10 millimeters in diameter is pressed against it by a known force. This force, in kilogrammes, divided by the area of the indented surface in square millimeters gives the so-called Brinnel ball hardness number. Prof. Turner's scratch test is made with a diamond-pointed lever. The weight in grams which has to be exerted downwards on the diamond, in order that it shall, when moved over the specimen, produce a scratch one-hundredth of a millimeter in width is taken as the hardness number. In the scleroscope a diamond-faced hammer, weighing about 40 grains, is dropped on the specimen from a fixed height. The hammer rebounds, and by the height to which it rises against a fixed scale the hardness of the specimen is measured. It thus appears that the Brinnel test is influenced primarily by the crushing strength of the specimen and the scratch test primarily by the shearing strength. The scleroscope test may be said to be influenced primarily by the imperfection of the specimen's elasticity, particularly so if, as seems to be the case, it is essential for the success of this test that a permanent indentation should be left on the specimen by the fall of the hammer. No doubt in each case the figure arrived at is influenced in a very complex manner by properties of the specimen other than and in addition to that mentioned. Nevertheless, it is reasonably clear that the three methods do not and cannot all measure the same property or the same combination of properties. This deduction is strengthened by noticing the "dimensions" of the respective hardness figures. The Brinnel number is really a stress, that is to say, a force divided by an area. The scratch test number is a force. The scleroscope number has the dimension of a length, but more properly it is to be regarded as representing an amount of potential energy. Many experiments have been conducted with the object of deducing a relationship between the Brinnel and the scleroscope numbers, and it is commonly believed that the Brinnel number, divided by six, is approximately equal to the scleroscope number for the same material. Recent careful experiments on the point, conducted on thirty-three different samples of steel and two samples of bronze, show an average ratio of 5.94. The variation from the average is, however, at times considerable. Thus, in seven cases the ratio is 5.5 or less, and in one case it is as low as 4.0. In seven cases it is 6.7, 6.8, or 6.9, the latter being the highest figure recorded. The relationship, if one exists, is therefore subject to considerable variation.

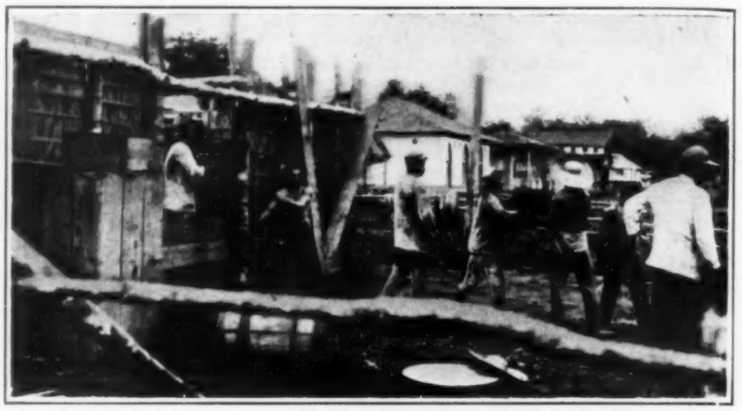
Until we are able to define hardness, it will be impossible to say whether or not our present means for measuring it give reasonable results. The scientific definition of hardness is, however, a matter very largely of academic interest. The practically important point is that we should be able to answer the question, Is hardness, whatever it is, really a criterion of the resistance to wear possessed by a metal, or, to be more precise, do the means in existence which are commonly regarded as measuring "hardness" give us a measure of the resistance to wear? There is no very apparent reason, physically speaking, why hardness and resistance to wear should be identical, or even be in fixed relationship. Experimental evidence is available on this subject, and clearly points to an entire absence of identity or relationship at least between "hardness" as measured by the Brinnel test and resistance to wear as measured in a machine specially designed to produce wear by sliding abrasion. In the experiments referred to the wear on the specimen was expressed as the thickness of the surface layer in mils worn away per 1000 feet of slip between the specimen and the body causing wear. The reciprocal of this figure was taken as the resistance of the specimen to sliding abrasion. For the same series of steels and bronzes, as referred to above, the ratio between the Brinnel hardness number and the resistance to sliding abrason as thus determined was found to vary not only considerably, but quite erratically. It might be as low as 0.7, or it might be as high as 64. Of two materials, both having a Brinnel number of 206, the resistance to sliding abrasion in one case was 48 and in the other 80. One specimen of steel, having a Brinnel number of 330, had a resistance to sliding abrasion of 500, while another, having a Brinnel number of 332, had a resistance of but 24. Clearly, then, it is almost impracticable to deduce from the Brinnel hardness number of a metal its relative wear resistance. In saying this, we do not wish to convey the impression that the Brinnel, and, by implication, the scleroscope methods of testing for "hardness," are of no practical value. The contrary is quite clearly the case. These methods give us a very ready means of ascertaining in the workshop whether or not our materials are being kept up to standard. It appears undesirable, however, to speak of the figures obtained from these tests as the "hardness" of the materials tested. This term should, we suggest, be defined, as it is interpreted in practice ninety-nine times out of a hundred, as the resistance of the material to wear. By so doing we would be left to seek a practical workshop method of quickly determining "hardness," but we would obviate the risk now in existence of being seriously misled over a very important matter.

*The Engineer.

Concrete Vessels

SENSATIONAL paragraphs have been appearing in the daily press in regard to a barge that has been built of concrete in Norway, and which it is stated to be the first vessel ever constructed of that material. This is entirely erroneous, for a boat of this description was built in France in 1849, and many others of the same kind have since been built in various countries.

Loading Brazil nuts for transportation down stream to some steamer landing.



Storing Brazil nuts in the crib-like structures locally known as paises.

The Brazil Nut of Commerce

How It Grows: And How It is Gathered

THE Brazil nut of commerce is really neither a nut nor ia frut. In common parlance one would describe a nut as a seed with a hard shell inclosing a kernel, which exactly fits the Brazil nut. In the strict botanical sense of the term, it will have to be defined as a fruit consisting of a harsh pericarp surrounded by bracts at the base, of which the acorn and the filbert are good examples. The so-called Brazil nuts are seeds and not fruits and cannot, therefore, correctly be called nuts. The merchant, the broker, and the man in the street are often very lax in their designation of articles in the trade and for them the definition will have to be extended to include all the products that are called nuts of commerce. Under any name, however, the kernel of the seed, which is the edible portion, is well known in this country as an article of dessert. In the trade Brazil, Para and cream nuts are a few of the more common designations. Originally these seeds were exported chiefly from Para and, therefore, came to be called Para nuts. The Portuguese in Brazil call them castanea, castanha, castanheiro or castanheiro do Para, which are terms meaning nut. In Venezuela they are called juvia.

The tree producing these seeds is known botanically as *Bertholletia excelsa*, a member of the monkey-pot family of plants, so-called because the type specimen of this group produces large fruits commonly called monkey pots. This Brazilian tree is one of the most remarkable plants of this large order. It is known to attain in many instances gigantic proportions. The mature trees range from 100 to 125 feet in height and from 2 to 4 feet through. The branches do not appear until near the top where they extend outward and upward in an irregular manner as shown in the illustration. Its leaves, which are of a brilliant green, are simple, arranged alternately upon the branches, and very large, measuring about 2 feet in length and from 5 to 6 inches wide. The flowers are yellowish white, more or less inconspicuous, and the fruit, which is produced in the upper branches, is a massive, urn-shaped pod or capsule from 4 to 6 inches in diameter.

As the name implies, the Brazil-nut tree is a native to Brazil, where it grows in small groups over an extensive range of territory. It is claimed that the tree is found all along the Amazon and Rio Negro rivers and likewise about Esmeraldes on the Orinoco River. Practically the only information now extant on the distribution of this important tree has been obtained from Indians and others who have been collecting seeds for the market. How nearly correct these statements are is difficult to say, but it is known that the tree does not form forests to the exclusion of all other species; it grows among other trees in the forest which covers many thousands of square miles. The areas on which clumps of Brazil-nut trees grow—often up to several hundred in number—are called castanhals or nut orchards.

The fruit of the Brazil-nut tree constitutes an object of considerable interest. It resembles somewhat the coconut in shape and size and has an exceedingly hard and woody shell that is about one half inch thick. When ripe they fall to the ground and the Indians and other inhabitants who gather them, split them open with an ax or machete and gather the seeds for market. The seeds, of which there are about twenty or twenty-five in each pod, are so beautifully packed in the shell that when they are once removed it is practically impossible to replace them with the same regularity. The large woody capsules are so hard and durable that the Indians use them occasionally as drinking cups, pots and dishes. The Portuguese tinners make boxes and other small articles out of them. The seeds, however, form the chief commercial product of this tree and immense quantities are being collected every year for the markets. A recent traveler in Brazil gives the following interesting account of the method of gathering the seeds: "Early in January the harvesting parties set out to gather the crop. As the only means of transportation in North Brazil is by water, these parties travel in canoes up the smaller tributaries to the castanhals. Arrived there, the pods are assembled at the foot of the trees, and broken open with the machete, after which the nuts are carried in baskets to the canoes which, when loaded, are taken down the

A cluster of Brazil-nut trees, showing their characteristic branching and shape of crown.

small streams to the larger rivers navigable by steamboats. As the river steamers are unable either to maintain regular schedules or await the arrival of gathering parties with nuts, it is necessary that the nuts be left on the river bank in what are known as "paioes." These paioes consist of cleared spaces protected from the hot sun and tropical rains by palm leaf shelters. However, these paioes are inadequate and, in consequence, the nuts sustain more or less injury at this stage, according to the length of time they remain in the paioes.

In a few districts, the custom of washing the nuts prevails. The method now in vogue is the same as was employed generations ago. In these districts, when the canoes arrive from the castanhals, the nuts are transferred from the smaller boats in small wicker baskets, which are immersed in the stream several times. By this process the accumulated dirt is washed off and imperfect nuts rise to the surface and float away. The cleaned nuts are passed on to the larger canoes or lighters and are transferred to the river steamers for transport to Manaos and Para.

Brazil nuts formed an important article of trade already in the early part of the nineteenth century. According to information published in the *Pharmceutical Journal* for 1875, the quantity of seeds exported from Para alone amounted in six months of the year 1833 to about 60,000 bushels. This did not include the large quantities exported from the Orinoco, Demerara, Cayenne and Maranhao rivers. At that time the seeds sold in England for about $7 a bushel. The price at which they enter the United States at the present time is only $3. According to Mr. C. F. Carter in the December issue of the *South American*, the Brazil nuts from Para, Manaos and Itacoatiara during the period from January 1st to June 30th, 1915, amounted to 407,687 bushels. Of this total 188,542 bushels were from Manaos, 38,117 bushels from Itacoatiara, and 181,028 bushels from Para. Manaos shipped 100,890 bushels to Europe and 87,652 to American ports, Itacoatiara 24,274 to Europe and 13,843 to this side of the Atlantic, and the respective figures for Para were 87,496 and 93,532. The total exportation to Europe was reported to be 212,660. and to American ports, 195,027.

The statistics of the Department of Commerce and Labor show the following amounts and values of the Brazil and other nuts imported into the United States from 1909 to 1914, inclusive:

Year.	Amounts.	Values.
1909	407,719 bushels	$761,219
1910	461,496 "	1,251,738
1911	283,902 "	804,064
1912	21,539,508 pounds	1,094,671
1913	11,933,445 "	668,534
1914	20,423,497 "	1,075,907

According to United States Consul Pickerell of Para, Brazil, the crop of Brazil nuts this year will be less than half of last year. Reference is made to this shortage of the crop in the *Folha do Norte* of Para, which reads as follows: "The merchants trading in this class of products are completely disappointed, because the effect of this small crop will be to upset the economic life of the municipalities of Obidos and Alemquer. From the notices we have received from the rivers Curua and Trometas, where the largest forests of Brazil-nut trees exist, a very small amount of nuts will be produced, due to the lack of rains during the months of March and April, the time in which the Brazil-nut trees are in flower. It would seem that, notwithstanding the war, the small crop of nuts will fetch a high price.

Protecting Metals

AN anti-corrosive grease, readily soluble in benzine even at the end of several months, can be prepared by emulsifying an aqueous solution of chromic acid or chromates with hydrocarbons, saponifiable fats and oils or the like. The fatty constituents serve as an adhesive, while the chromic solution, it is claimed, prevents rusting. Equal parts of fat and a five per cent solution of sodium bichromate are triturated in a mortar. This makes a viscous paste which keeps iron plates bright for several months, and is easily removable with benzine.—*The Engineer.*

A ripe Brazil-nut pod.

Enzymes—Substances Which Transform Food Into Body Constituents

By Jokichi Takamine, Jr.

To probably ninety per cent of people the word "enzyme" means nothing. They have either never heard the word used or have not bothered to learn what it meant if in some way they did happen across it.

In the schools and universities we all learn what an acid or alkali is—that when mixed they form salts—and many other facts in the arts and sciences which are interesting to know, but which, most often, are not personal; but of enzymes, those marvelous bodies which bring about the most vital transformations and carry on our life processes themselves, we are ignorant. How or why they act, where they come from, is known by only a few of even those who know what the word "enzyme" means.

We all know about the automobile or machine engine, that if there were no tiny spark, caused by unseen and unknown electrical forces, there would be no explosion of the energy containing gas, and the engine could not run. Here is a direct analogy with our body engine. The enzymes, acting also with unseen and unknown force as the spark, bring about almost directly the combustion of the food fuel, thus enabling our body engine to run.

The study of enzymes is still in a problematic stage—all the problems of the transference of energy in animals or plants, or, in other words, of life, are in some way bound up in the doctrine of enzymes. In other words, the unaccountable, undefinable and unseen force which keeps our life processes running smoothly is the same which activates certain organic substances, enzymes, to perform marvelous feats in metabolism or the reconstructing of substances useless in their present form, into those upon which our very life depends. Thus, without enzymes, without life. As yet, I have not mentioned a definition for an enzyme; in a few moments you will see that it is almost as difficult to define as electricity, for which there is no clear definition.

From the earliest ages "fermentation" or alcoholic fermentation, has been the cause of conjecture. Basilius Valentinus regarded the fermentation as merely the process of purifying the alcohol already present. Explanations were made which were satisfactory to the period of believers in miracles; then new definitions arose through different ages, all of which are excused by the limited knowledge of those times—and even to-day we are not agreed—and the scientists of the future will, no doubt, ascribe the explanation of 1916 to limited comprehension. However, from about 1875 these substances were studied in a more systematic manner and from that time two chief theories have been held; one that enzymes are a property and the other that they are a substance. Arthus, as late as 1895, compared their properties to those of heat, light and electricity and cited examples. Green asserted they contained some "vital force," which explains nothing. E. Buchner was the first to isolate the enzyme from the yeast cell and showed that its activities were not confined to the living organism. Amand Gautier showed that enzymes as substances showed specific chemical reactions and tests. For example, the enzyme called emulsin always gives a violet color with orcin and a red color with Millon's reagent, etc. The combination of the two theories of substances and properties seems to me to be the best for defining an enzyme. Thus an enzyme is an organic compound substance embodying a peculiar form of energy which is produced by living cells—whose activity is the same whether liberated or bound up in the vital process of the cell.

Before attempting to go into details about enzymes it is best to describe some of their properties as a class, because in many instances these properties are alike, and we may note that in many respects their activities are limited as are those of living creatures; and just as in life, if these restrictions are violated the result is injurious or fatal. The temperature at which they thrive and act normally is about the same as that under which living germanisms exist, 35 deg. Cent. However, just as life can go on in hotter climes, these enzymes also can do the same. So we have an optimum activity at 50 deg. Cent. Beyond this temperature, however, their action is injured, and at 100 degrees their activity is *nil*. Some are active only when the medium in which they work is acid, some where it is neutral and still others where it is alkaline. As you will see later this is fortunate. In the presence of certain poisonous inorganic salts they are rendered quiescent, their powers being killed; examples of these salts are $Hg\ Cl_2$ K Cn, which are equally fatal to living organisms—they are usually soluble in water and in cold temperatures their activities cease.

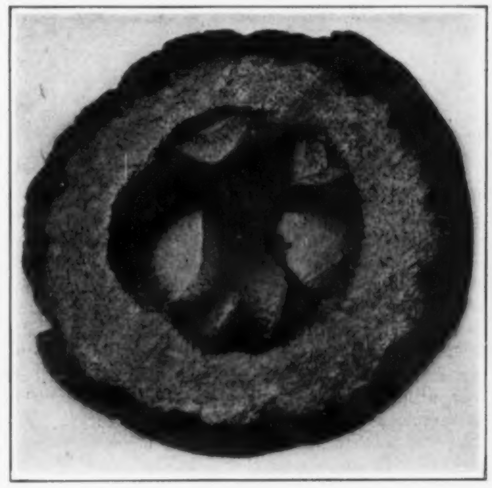
The action of enzymes is so widespread through nature that it would take a very long time to even summarize their activities, so instead of straying off in this field we will confine ourselves to the part they play every day and are playing at this moment in the nutritive economy of our very life.

Some enzymes play a most important part in our digestion since they transform the foods which in their natural state are insoluble and non-assimilable matter into such similar products which are nutritive and can be absorbed into the system to build up tissue and protoplasm or split up to give the kinetic energy required for heat.

As we would visit a factory from the beginning and see the various crude products, often useless in their raw state at the start, and we follow their journey on and see the many intermediaries, such as acids and alkalis, carrying on processes and transformations, thence to the final product, which is something very different and nearly always more useful than the initial substance or substances. We see a direct analogy here to the digestion, with the food as the raw products, the body as the factory, and the enzymes as the intermediaries carrying on the process of synthesis and decomposition and forming new substances which are most useful and essential to life.

The raw products which go into the body factory, for example a food compound containing the three essentials, carbohydrates like starch, proteins like meat, we shall follow their course in the body factory and examine the processes through which they go.

Starting in the mouth cavity the food is chewed and here the first intermediary, ptyalin, starts its work. Ptyalin, as designated by Berzelius, is contained in the saliva, and being an amyoclastic enzymic, has a specific action on carbohydrates like starch, acting on that subject alone. Leuchs in 1881 discovered that ptyalin converted starch into reducing sugars. I mention this date to show for what a short time only this important fact has been known. Thus we learn that the function of ptyalin is to convert starch into maltos and dextros. The action of ptyalin is carried on in a slightly alkaline solution—such is the case normally in the mouth. Of course, the action starts immediately, but is very slow, increasing almost proportionally with the time up to twenty-four hours, depending upon the concentration. Hence it is very essential to chew the food well and to mix it intimately with the enzyme. Concerning the concentration, an idea has been exploded recently through research work at the University of Chicago, to the effect that drinking water with the meals is not beneficial. Doctors prescribe drinking between meals, but these recent works have shown that the attenuation of the medium on which an enzyme may act brings about a greater action of that enzyme; for instance, one gramme of sucrase placed in a solution containing 5,000 grammes of sugar might convert 2,000 grammes if the solution were concentrated, but the same amount of sucrase would convert 4,000 grammes of sugar if the same solution were made more dilute. Hence, it would be advisable for any one trying to reduce not to drink water with their meals. Now this action on the starchy matters is carried down the alimentary canal until it reaches the stomach, where the medium is acid and the motion of the ptyalin is inhibited and here begins the action of the proteoclastic enzymes. The first of these we encounter is pepsin, designated thus by Schwann in 1836, secreted from the fundus glands according to Wittich, and from the mucous glands of the pylorus according to Ebstein. Here all the albuminous matters are attacked by pepsin and eventually these indiffusible bodies are changed first into albuminoses and then into diffusible substances—peptones. As meat is the main food that comes under this category of protein substances, I might state for the benefit of those who are vegetarians entirely that in excess, it is harmful both mentally and physically. A protein is an organic compound containing nitrogen. Practically all the substances which go to make up the body, i. e., tissue, blood, etc., contain nitrogen, especially the nerve centers and the brain. We have a very clear demonstration of the effect of an entirely vegetable diet shown in the Japanese army, the food consisting mainly of rice. A disease broke out known as beri-beri, the cause of which was discovered by Baron Dr. Takaki to be the starvation of the system of nitrogen, and the only cure was feeding the patient with nitrogenous or protein food. The pepsin on the market to-day is obtained from the lining of pigs' stomachs.



Pod cut open, showing the seeds.

Next we come to digestion in the intestines, where the most important actions take place, the others being preliminary. We have again come back to an alkaline medium, and here we find the decomposition of albuminous substances completed by the action of trypsin, named so by Kuhne, an enzyme secreted by the pancreas. This acts upon the albuminous matter partially decomposed by pepsin, and also the proteins unattacked by pepsin, and reduces them to amino acids and hexone bases. These are complicated organic nitrogen compounds, and the formulæ of many have been discovered and some have been synthesized by the wonderful work of Emil Fischer and others. The formulæ of these has taxed the ingenuity and imagination of these great chemists, and yet these decomposition products are as simple as a-b-c in comparison with their original formula. As I mentioned before, all the starchy food could not be converted in its short duration in the mouth; in fact, only a small portion is converted. The remainder is again attacked here and partially converted into resorptionable mono-saccharides by an enzyme amylopsin. There still remains only the fats, which have not as yet been attacked in the journey, and here in the intestine they are attacked by the enzyme lipase, also secreted by the pancreas, which resolves them into glycerin and free acids; this acid is saponified by the alkali in the intestine and rendered soluble. Thus we have seen that the carbohydrate is changed into soluble assimilable sugars by the enzymes ptyalin and amylopsin. The albuminous matter changed into soluble peptones and amino acids by pepsin and trypsin and the fats changed to glycerin and free acid by enzyme lipase. Finally, it may interest you to know why drinking intoxicants retards and stops digestion. It is because the alcohol atrophies and injures the glands in such a way that it impairs their power to secrete properly.

In summarizing, we have seen what an important rôle they play in our daily welfare, but this is only one of the many fields where these marvelous bodies carry on their work. Enzymes are also embodied in practically all plant life carrying on the marvelous duties of metabolism. Some of these enzymes of plant life have been isolated and are substituted by your physicians when they are needed and where your glands secrete an insufficient quantity to perform their duties properly.

In the near future we may hope to be able to carry on your digestion by these isolated enzymes so that should all the digestive glands in the body stop working you would have naught to fear.

Palæontology*

Its Aims and Methods

By D. M. S. Watson, M.Sc., F.Z.S., Lecturer in Vertebrate Palæontology, University College of London

Palæontology is, by definition, the study of the remains of living things buried in the rocks. Dealing as it does with such material, which, also by definition, falls within the scope of the biologist, it is not surprising that on many occasions and by many able men its claims to distinction have been dismissed, and it has been treated as a subordinate and inferior branch of the larger science. Such treatment, however, although it has been advocated by distinguished palæontologists, is unfortunate; the discovery by William Smith that "Strata could be identified by the organized fossils which they contain," one of those great fundamental truths that we owe to British science, gives to our subject an obvious and fundamental connection with stratigraphical geology, and subsequent events have shown the light which a study of fossils may throw on the conditions under which rocks were laid down, and on the geographical changes which are associated with their origin. This important bearing of palæontology on geology has often been advanced as the basis of its claim to distinction. Such evidence is, however, not a sound foundation. Whole regions of chemistry and physics have an equally important bearing on geology, but are not on that account raised to independent rank. Recognition of a science as an independent branch of study must depend upon a fundamental, philosophical method peculiar to it. From a practical standpoint it is now usual to divide the subject into a botanical and a zoölogical half, but such division is purely an artificial one, and the philosophical method of each is similar.

If we consider the history of palæontology we find the rapid establishment of two divergent interests, one, which in the early days was largely confined to those who studied vertebrates, being concerned solely with the morphology of the animals or plants with which it dealt; the other, predominantly held by men who were primarily stratigraphers, using their fossils merely as dating objects for the rocks in which they are found. The latter form of study had, until recently, no philosophical background; it was purely empirical, arguing solely from observed occurrences of individual types whose history was not only unknown but not even inquired into.

The morphological side of palæontology very rapidly acquired a distinct meaning; in the hands of Owen it was used to support, and to be in its turn assisted by, the "Archetypal theory." By the use of this theory, which unconsciously at first, but knowingly in its later and degenerate days, was distinctly evolutionary in its outlook, Owen was led to the correct appreciation of many homologies, to the distinction between homologous and analogous structures, and to an understanding of relationships which is often so accurate and so in advance of his time as to be uncanny.

The coming of evolution and its general acceptance gave a new meaning and a new interest to the many facts collected by Owen in relation to his archetypal theory; they fell at once into place as the evident result of evolution, whatever its method.

The first palæontologist to adopt a definitely evolutionary outlook in his work was A. Gaudry; but the full development of a philosophical method based on the fact that every organism is the modified descendant of a long line of ancestors was due to W. Kovalewsky, Professor of Palæontology in Moscow, who by this great achievement established an irrefragable claim to be called the second founder of this science.

Reduced to its ultimate terms the method of Kovalewsky is this: Palæontological material to be valuable must be of a special kind; it must consist of a series of forms which either actually stand to one another in the relation of parent and child or are close blood relations belonging to different generations. Direct comparison of such forms with one another will show differences which may be due either to the fact that the animals compared are not really parent and child or to the evolutionary change which has taken place between the generations studied. It is the business of the student to discover the real direction of the evolution and finally to sum up his work by the construction of a genealogical tree.

Such is the primary aim of palæontology, the tracing of lines of descent. The same object lies before the taxonomist, but difference of material leads to a corresponding diversity in method. The two students differ, as do the historian who has as his material documents the age of which is known and the modern social anthropologist who must reconstruct the past from the actually existing organization, customs, and traditions of his people.

The historian and the palæontologist by their direct and contemporary evidence have certainty of order so far as their material extends, and an abundance of detail; the anthropologist and the taxonomist can only reconstruct the broad outline of history and are at best uncertain of the relative periods at which changes in structure, of society, or of an organism respectively have come about.

Were the preserved contemporary documents complete, covering the whole field of study, the construction of a history would be a simple process; but their fragmentary nature, with whole periods unrepresented by documents, and many even of those which have been spared to us mutilated, renders their direct interpretation difficult.

The incompleteness of individual items cannot be overcome—we have to take them as we find them; but for the filling in of the gaps we can fall back on the methods of the anthropologist or the taxonomist.

These methods depend on the fact that indelibly impressed in structure are the traces of former conditions. The full realization of the truth of this doctrine, so far as it concerns biology, was due mainly to the work of two palæontologists, A. Hyatt and L. Dollo, to the latter of whom we owe its clear statement and a demonstration of the possible extent of its use.

The method of Alpheus Hyatt depends on an application to fossil material of the theory that "ontogeny repeats phylogeny," the view perhaps first stated by Louis Agassiz, that an animal in its youth repeats the adult conditions of its ancestors. When applied, as it always has been by embryologists, to the reconstruction of structures occurring in very remote ancestors, this theory has seldom proved useful (its most striking success being Reichert's theory of the mammalian auditory ossicles), because early stages are usually very much obscured, partly by the thrusting back into them of structures which really belong to much later times, but which by their actual physical bulk require a lengthy development, and partly by modifications imposed by functional needs of the growing organism.

The palæontologist uses this recapitulation only to bridge over slight gaps; the stages he uses, living under similar conditions to the adult, are free from special embryonic features. In most cases the characters used are not in all probability of much functional importance to the animals, being generally ornamental structures.

The study of phylogeny is beset by many difficulties and pitfalls. The determination of the actual relationship of two animals, whether they be closely allied or remotely related, is seldom easy, resemblances of many distinct kinds having to be sorted out and differences evaluated. The experience of a century of study has shown that in the case of distantly allied forms gross resemblances, those which are obvious to all, are usually misleading, because owing to their very patency they have come into direct contact with the organism's environment and have been modified in adaptation to it in similar ways in diverse phyla. Palæontologists have thus been thrust into a thorough study of detail, an investigation far more precise and deep-seated than any undertaken in pre-Darwinian days; they now look for significant resemblances in those inconspicuous structures often of vital importance to the animal, which by their deep-seated nature may be supposed to be protected from adaptational change. These characters, however, by their very nature are common to all individuals of great groups and cannot serve for the finer separation of the members of the smaller twigs of a phylogenetic tree; for such distinctions other characters, also not likely to be affected by adaptation, must be chosen, and the very fineness of the divisions they are to be used in making renders it necessary that they should not be of any great importance in the animal's life.

The study of phylogeny, therefore, demands the searching out of deep-seated structures essential to the animal's life for the distinction of the greater groups, of the patent features of the animal and the investigation of its adaptations for the further sub-division of these groups, and finally of the small, non-adaptive details of its make-up for the disentangling of those distinct but nearly allied phyla which are the smallest groups we need recognize.

The phylogenies so constructed, broken and incomplete as they must always be, and inaccurate either in grand features or in detail as they are, make closer and closer approximations to the truth as reliable material becomes more abundant and as the methods of its study become more refined.

Such histories, whose formulation is the primary aim of the palæontologist, may be used in many ways. They serve as a check to evolutionary theories, bringing them to the bar and confronting them with new series of the actual facts which they are intended to explain. They enable us to see and study the gradual improvement of an animal mechanism; to trace how, while retaining its capacity for performing its function at every stage, it gradually changes until it may be easily adapted to some quite new and highly special purpose.

The many phylogenies which have been studied by palæontologists during the last thirty years, whether they were actually expressed or remained implicit in the published work, have many features in common, features which distinguish them from the early efforts of zoölogists and which remained unsuspected until they were abundantly revealed by palæontological evidence.

Palæontological phylogenies are of the most diverse kinds; they may represent the real development of some very restricted group, or they may deal in a broad way with the development of orders and superorders. They have been investigated in all groups of animals both vertebrate and invertebrate.

The fact that students of echinoderms and vertebrates produce phylogenies of similar type, and find that these agree in character with those which represent the histories of groups of cephalopods and brachiopods, shows that the underlying factors which have determined the evolution are similar in all groups. All modern carefully investigated phylogenies founded on palæontological data agree in the following broad features:

1. That in any one line evolutionary change, especially of those regions of the body which do not seem to show adaptation to any special mode of life, proceeds steadily, no matter what the stock's changes of habits, as if from the first devoted to the production of a definite final structure, and that it is hence legitimate to speak of an evolutionary trend.

2. That an evolutionary trend is irreversible. Once committed to a course of evolutionary change a stock must follow it to the end, and as it does so its power of giving rise to branches with diverse trends becomes more and more reduced. In consequence of this loss of potentiality the greater groups, which are really initially distinguished only by their different trends, necessarily separate very soon after the establishment of the group from which they spring.

3. That in consequence of the imposition of a phyletic trend allied stocks pursue parallel series of changes, the accuracy of the parallel depending on the closeness of the relationship, and that in consequence, as Prof. W. H. Lang puts it, modern phyletic representations more resemble a bundle of sticks than a tree; the separate lines tend to radiate from a point and not to arise separately from an axis.

4. That the rate of parallel changes in allied stocks, and the relative rate of these changes of different regions in the same stock, may differ considerably.

5. That the mode of life is liable to complete changes and reversals: a stock may begin in the water, take to the land, launch out into the air, and then return again to the earth and even end with a life as thoroughly aquatic as that with which it began. Such an animal will retain in its structure features which it has acquired in every stage of its history, most clearly of course those of the later stages, but less and less clearly the results of the adaptations of its earlier ancestors.

6. That certain insignificant details of structure similar to those with which the Mendelian deals, and on which the systematist founds species, may persist

*Science Progress.

unchanged through considerable changes of the animal's fundamental structure.

7. That certain features, to all appearance as unimportant as those which are usually regarded as only fit to separate species, not only change in definite directions but seem to retain this trend in all animals whatsoever. The classical case described by C. E. Beecher concerns ornament. Stocks which begin by being smooth, if they develop two sets of ornamental ridges which cut one another will develop tubercles at the intersections, which will subsequently become spines, only to return to tubercles and finally to a smooth stage in the animal's second childhood.

It is not my purpose on the present occasion to discuss the bearing of these facts—for they are observed facts in spite of the necessarily somewhat mystical style of their presentation—on current biological theory. Nevertheless it will be obvious to all that they reveal the very great insufficiency of many favored hypotheses.

The fact that the evolutionary change of any structure is not haphazard but proceeds along a definite track gives us a real foundation for the finer division of geological time on palæontological evidence. We have only to take some phyletic series which is really known, and divide the rocks in which the remains of its individuals are found into zones on the stage to which the evolution of some particular structure has proceeded. Simple as this process is in theory, it is impossible of direct practical application, because of the difficulty of distinguishing between the members of allied stocks pursuing parallel courses of evolutionary change, a difficulty which probably increases as the number of independent variables which can be observed becomes smaller, being least, though even then very serious, in vertebrates and increasing in echinoderms, brachiopods, and cephalopods down to such things as graptolites.

In practice, in most cases it is necessary to use all members of allied stocks which will differ to a greater or less degree in their rate of change. There is evidence that an animal which in any one structure has progressed more rapidly than its relatives will have fallen behind them in other directions; a horse with unusually progressive teeth, for example, may have retarded feet.

In this way, by taking many species of allied stocks found in the same bed and averaging up, first the stage of each and then that of all, we may be able to found definite time divisions, the size of which will depend on the closeness with which we restrict the animals we use to a single phyletic stock.

The more satisfactory attempts to "zone" a series of rocks do really depend on the conscious or unconscious use of this method, which is destined to play an increasing part in stratigraphical geology as the number of students of modern palæontology increases and as the determination (with greater or less accuracy) of a miscellaneous collection of fossils ceases to be regarded as a necessary or indeed the essential function of a palæontologist.

The view of the true method of using fossils as geological time indicators developed in this essay leads to a justifiable doubt of the value of plant evidence in the discussion of the smaller divisions of geological time. With one exception no phyletic series of fossil plants, even of the broadest nature, has been established. Nothing whatever is known of the evolutionary trend of any of the plants found so abundantly as impressions in the rocks, and the number of independent variables which can possibly be recognized in such materials, which alone can serve the purposes of geological work, is so small that the separation of allied stocks would be almost hopeless, even if phyletic trends could be established.

It therefore seems essential for the further development of the geological uses of fossils, as it is for their biological interest, that palæontologists should concentrate on the detailed study of zoölogical groups, preferably of common fossils, with the primary aim of discovering their true relations to one another, that is, of producing phyletic diagrams. The family histories so established will directly fill all the needs of the geologist, who will have the unfamiliar sensation of using evidence the nature and meaning of which he understands and the probable value of which he will have data for estimating.

All the uses of palæontology may thus be provided for by a single comprehensive study, and that this study must be founded on the recognition of the unique feature of palæontological material, that the relative ages of its subjects are known, is the only real foundation of its claim to distinction.

The Oaks of America*

By William Trelease

For a number of years I have been engaged in a study of the oaks of tropical America. These have not been treated comparatively for a generation, with the result that the extensive collections made within that time have gone into herbaria largely unnamed or wrongly named. My feeling has been that the only way to unravel the difficulties was to begin with the study of types of the earlier species, passing to those of later date and deferring examination of unauthentic collections until the end. Though it was not possible to carry this plan out in all detail, it has been my privilege to see most of the types of tropical American species, and to photograph in natural size representative parts of them whenever found, so that whatever errors may have slipped in, they scarcely include a misapprehension as to what is meant by the earlier used names except for one or two of Née's species of which no identifiable material is known to remain.

It was not until this study of the forms that occur to the south of us had been essentially finished, that it seemed best to include in my treatment those of the United States. These have been so long and so repeatedly studied and for the most part figured that little would seem to have been left undone with them. Yet within the year Prof. Sargent has pointed out a serious misapprehension as to the proper Latin names of the rock chestnut oak and the cow oak, and has made it very questionable whether what we know as red oak in the Northern States is what Linnaeus called *Quercus rubra*. As I finish my manuscript, in which for completeness the Northern oaks are included summarily, I have a feeling that more uncertainty still attends several of these polymorphic species than perhaps any one which occurs in the tropics; and unfortunately this uncertainty for the most part cannot be removed by reference to types, which do not exist for the most puzzling of these Northern species.

A careful analysis of the characters presented by wood, inflorescence and flowers leads me to believe that the Fagaceae are far from being the primitive plants that they are commonly taken for, and I am disposed to conclude that their affinities are with such seemingly advanced and certainly specialized but still really simple orders as the Ranunculales and Rosales, from the type of which they have receded.

On this continent, the oaks (excluding *Pasania* as a distinctly separable genus) seem to fall into three subgenera or main groups instead of two as usually understood, Leucobalanus, the white oaks, typical of *Quercus*; Erythrobalanus, the red or black oaks; and Protobalanus, a more ancient type as I conceive it, comprising the protean intermediate assemblage clustering about *Q. chrysolepis*.

Summarized, my study of American materials contained in the principal herbaria of the world leads to the recognition of 354 species, of which 158, or very nearly one half, are described as new in the manuscript which I am now prepared to submit to the Academy for publication, in which 183, or slightly over one half of the whole, are figured for the first time. As in our immediate flora, white and red oaks occur in approximately equal numbers for the American flora as a whole: 170 species of the former, and 179 of the latter, only four species of Protobalanus being known.

In variety as well as in actual number of species, the countries to the south of us are much richer in oaks than the Atlantic United States—a result to be expected from the more rugged configuration and greater meteorologic differences in those countries. The principal facts of the distribution of American oaks by countries are indicated in the following table. A very few species occur in more than one country, and therefore are counted for both.

Country	Leucobalanus	Protobalanus	Erythrobalanus	Total
United States.....	43	2	26	71
Mexico	121	2	125	248
Central America..	20	0	35	55
South America....	0	0	4	4
Antilles	1	0	0	1
Pacific Islands....	0	1	0	1

A glance at this table shows that, rich as the United States are in oaks, they are nearly equaled by the small Central American countries and far surpassed by Mexico. In the West Indies only a single species of white oak, doubtfully distinct from the live oak of our Gulf States, occurs, and this unquestionably derived from our mainland. In South America there are only four closely related species, of the red oak group, and these are clearly allied with some of the Costa Rican species.

The genus *Quercus* is conceded to have existed in Cretaceous time, though many Cretaceous and Tertiary fossils formerly referred to this genus are now placed in *Dryophyllum*, which is taken for the ancestral stock of the Fagaceae rather than of *Quercus* alone. Paleobotanists now admit 150 species of American fossil oaks pretty evenly distributed through the Cretaceous and the Eocene and Miocene divisions of the Tertiary. Few Pliocene fossils are known for North America; but in South America, where a few others have been made known for the Argentine, four species have been described from Pliocene deposits of equatorial Brazil. It is noteworthy that the few existing South American oaks are confined to the Andes of Colombia.

So far as I know, none of the earlier species survived from one to another of the periods of geologic time except for *Q. furcinervis americana* (perhaps two distinct species) in Eocene and Miocene deposits, and that what has been taken for the existing *Q. chrysolepis*—the type of the subgenus Protobalanus—occurred in the Miocene; but this identification might well be questioned by a critic. A proper understanding of the affinities of existing groups of species undoubtedly calls for a just appreciation of their connection with these ancestral forms. This I do not profess to have formed. I find the occurrence of a few aberrants—among them the South American species—in the subgenus Erythrobalanus puzzling, but can see no satisfactory evidence that red or black oaks are recognizable in any of the older fossils; and the group is certainly exclusively American to-day. Notwithstanding this, a resemblance is observable between the white oaks of Europe and those of Western rather than Eastern America that proves puzzling.

On the whole, I am unable to trace any existing groups to those of Tertiary time. Pleistocene species, of which eighteen are recognized for the United States, as is to be expected are scarcely different from those of to-day, though they are sometimes given distinctive names. In the early Pliocene should be sought definitely recognizable ancestral forms of these and their living descendants.

Considering the multitudinous—and in their extremes very diverse—types of such an existing assemblage as that of the Rocky Mountains, in which Engelmann and other excellent botanists have been unable to see more than a single polymorphic species, and the comparable range—to which the keen von Ettingshausen refers the manifold European oak types of to-day—in the fossil *Q. Palaeo-Ilex*, I am unable to see that all of the existing American oaks may not have descended from a single synthetic type of this kind, such as the Miocene species that has been held to be identical with the existing intermediate oak *Q. chrysolepis*. Out of this type, rightly or wrongly, I have built the present divergent branches of white and red oaks as I understand their affinities, believing that the European and American white oaks have no direct connection and that on each continent the manifold and often parallel forms of to-day have been independently derived from distinct late Tertiary types not closely related to one another in descent.

*Proceedings of the National Academy of Sciences.

Hevea Rubber Tree

A series of careful observations were made upon the *Hevea Brasiliensis* at the Botanical Gardens of Buitenzorg, Dutch East Indies, on account of the interest which this rubber tree possesses as a source of this valuable product. The tree furnishes a nut which is about the size of a walnut, and Mr. André Sprecher studied the properties of the nut and its mode of germination, as well as the effect of outside influences on the germinative faculty, the size of the sprouts after a month's growth, and other points. He finds that a nut of dark color is better than a light one, and that the light has no effect upon the rapidity of the sprouting. Growth is best in the areas which are watered and kept under diffused light. The nature of the soil has no direct action on the phenomenon, but it enters in indirectly as a source of humidity or as a medium for microbe growth. A rather grainy soil with smoothed off surface is better than a fertilized soil. The extraction of the milk from the trees bearing the nuts does not seem to affect their quality. An analogous fact is noticed in the case of the sea-coast pine in France. It is noticed that moisture has a bad effect on the sprouting, and that the germ of the nut lasts twice as long in the dark as in the sun. Germination begins at 15 degrees Cent. and is under the best conditions at 30 to 35 degrees, ceasing at 45 to 48 degrees, but the sprout is not injured even at 50 to 60 degrees.

Photo by Press Illustrating Service, Inc.

Pouring molten bronze into a small mold.

Making Bronze Statuary

An Ancient Art That Is Still Prominent for Decorative Purposes

ALTHOUGH bronze statues and figures are among the most pleasing ornaments of our public parks and squares, and the same material is very extensively used for decorative purposes in both public buildings and private residences, it is seldom realized that bronze casting and modeling are among the most ancient of the metal-working arts, for articles of bronze, both decorative and implements used in everyday life, long antedate those of iron. This may be considered logical, for copper, which forms the basis of all bronzes, is much easier to melt and to work than iron, besides being of greater durability.

For decorative purposes bronze has special advantages, inasmuch as when melted it is very fluid in its consistency, which enables castings of great delicacy of detail to be readily made, and, moreover, the surfaces obtainable in castings are beautifully smooth, and the finished meta has a most pleasing color. The ancient Egyptians, who were notable for many different descriptions of art work, were particularly skillful in the working of bronze, and later the objects produced by the Greeks and Romans were famous for their beauty and excellence.

The term bronze is to-day very ambiguous, for it includes a great variety of alloys, mixed in various proportions according to the purpose for which the metal is to be used; and it is probable that this condition has always existed from the earliest times. In its simplest form bronze may be said to be composed of an alloy of copper and tin, copper forming the greater part; but many other metals are also added to the mixture, as zinc, lead and antimony. The ancient bronzes contained from 67 to 95 per cent copper, and, besides tin, traces of silver and gold have also been found, but it is probable that these gained access to the alloy as impurities, for it is not to be supposed that the workmen of olden times were able to produce very pure metals by the crude methods of extraction at their disposal. The superior color and finish, however, of many ancient bronzes is by some attributed to the presence of small quantities of silver in the alloy, whether intentional or not. On the other hand, we know that the Egyptians possessed secrets in bronze-making and working that have since been lost, as for example their hard bronze cutting implements which cannot to-day be duplicated; and it is possible that some of their apparently impure mixtures were made intentionally. Among the makers of bronze figures to-day it may be said in a general way that a mixture of copper, tin and zinc is ordinarily used, but each one has his own special methods of working, and special alloys are frequently prepared to secure some desired color in the finished work, or for some other reason.

It is very probable that casting was the earliest method of forming objects of metal, the molten metal being poured into a mold made of clay or sand, and the article produced was solid. Later on, in the case of bronze work, after considerable progress had been made in metal-working, an iron core was introduced in making objects of bronze, in order to economize in the material used; but it is probable that no statues of very great size were made at this time, both on account of their great weight and the large quantities of metal that would be required, for the melting of which it is not likely that facilities existed. But as experience in the arts progressed the present method of inserting a core of sand or clay in the mold was developed, the result being that when the molten metal was poured into the mold it formed a thin skin, just heavy enough for strength and to insure a perfect reproduction of the details of the mold.

Photo by Press Illustrating Service, Inc.

Cleaning the molding sand from a bronze figure after casting.

One of the earliest of the methods of producing hollow castings in bronze, and with which it is supposed the Greeks and Romans were acquainted, for they showed great skill in their work, was that later known as *à cire perdue*. This was the process employed by the great Italian artists of the sixteenth century, and is described by Cellini. The desired figure was first roughly modeled in clay, but somewhat smaller than the finished object. On this was

Photo by Press Illustrating Service, Inc.

Preparing the mold for the soldiers and sailors monument at Goshen, N. Y.

Photo by Press Illustrating Service, Inc.

At work on the mold of a hand and arm for the Goshen statue.

laid a layer of wax, and upon the wax the sculptor produced the finished details by careful manipulation with his tools. A mixture of clay, ashes and pulverized bricks was then prepared, and ground with water until it formed a thin paste, which was carefully brushed over the finished wax surface, working the mixture into every line and depression. When a sufficiently thick coating of the paste has been built up, soft clay is applied all over the prepared model, and built up until a sufficient thickness has been gained to form a mold, which was bound with bands of iron and then baked. This baking, besides drying the mold and core, melted out the wax surface layer and left the mold and core in their proper relative positions, with a space between to receive the molten metal, the core being held in place by a series of small bronze rods that were driven through the mold and core. After casting the metal and allowing it to cool, the clay mold was broken away from the outside and the core scraped from within. While this method produced excellent results, it is open to the objection that only a single reproduction can be made from the model, and, moreover, should any accident happen to the mold, or if the running of the metal prove faulty, the artist must do all of his work over again.

In the modern method of casting the sculptor furnishes the founder with a plaster cast of his figure, around which a mold of fine sand is built up in many pieces, so that the model can be readily removed without damage to the mold, and a sand core is built up within. When this is done, the sections of the mold are carefully matched together again and the metal is run in. By this method the original model is not injured, and as many duplicates as are required can be cast exactly alike.

It is popularly supposed that all the sculptor has to do is to create his design and embody it in a pretty little wax or clay model; but this is only a portion of his task, for he is responsible for the production of the full size plaster cast from which the metal founder works; and to make this is, in many cases, by no means a slight nor an easy undertaking. It is true that in his preliminary studies of the figure or group that he proposes to produce the sculptor first makes a small model, which is frequently of an impressionistic character, and lacking in many of the finer details; but when he comes to the real work his model must be on a much larger scale.

If the completed statue is to be reproduced in stone the model need not be of full size, but merely large enough to give every detail in its proper proportion, and from this the artisans who do all the heavy work of cutting can produce an exact duplicate of any size desired by laying out points by the aid of a pantagraph, while the sculptor puts in the finishing touches with files and small graving tools. When, however, the statue is to be cast in metal an entirely different mode of procedure is necessary, for he must not only make his model in full size, but must also make a suitable plaster cast for the use of the founder, and all of this means a great deal of careful and expert work.

Large figures are made of a special kind of plastic clay that is easily worked, and capable of being modeled to exact details; but this clay does not have the strength to maintain its own weight, especially where there are members extending out far from the main body of the figure, especially as the clay must be kept constantly moist to enable it to be modeled and to prevent it from cracking, which would happen if it became too dry. To meet this condition it is necessary to reinforce the figure by a supporting framework that calls for considerable ingenuity. Let us take for example the well known figure of Mercury, which we all know is poised on one foot, with the other foot and the arms extended to give the impression of motion. To prepare for the modeling of this figure a substantial plank base would be provided, and in this would be fixed a strong iron bar extending up through the entire figure to the head. Upon this bar is built up a framework composed of strips of wood, nailed and wired together, that conforms roughly to the general contour of the figure, including the extended limbs, and the head. Such a skeleton is crude in appearance, and often grotesque, but it fulfills its purpose and not infrequently involves considerable engineering skill in its design.

Upon this frame the sculptor builds up his clay, first producing the proportions roughly with his hands, and gradually working out the details with surprisingly few tools, which consist mostly of scrapers of various shapes, the smaller made of wood and the larger implements of steel and wire. Of the artistic details nothing need be said here, as that is a matter of individual ability; but when the clay model is completed it represents the finished figure not only in every feature and minute detail, but in size and proportions as well.

The work of securing the plaster cast for the metal founder is now taken up, and the first step is to build a rough mold of plaster that will enclose the clay figure, leaving an intervening space all around of about an inch. This mold cannot be made in a single piece, for then it would be impossible to remove it from the model, so it is carefully divided into sections, so located that each section can be drawn straight away from a surface of the figure without bringing other parts with it, and this work requires wide experience and ingenuity. When this mold is completed and in place, it is tightly bound together, and melted glue is poured in to fill the space between the rough mold and the finished model. When the glue has cooled and set the plaster case is removed, and with a sharp knife the flexible coating of glue, that now surrounds the clay model, is carefully cut with a sharp knife along the lines of the joints of each section of the plaster mold, and each glue section is carefully drawn from the clay model and placed back in its appropriate section of the plaster case. The glue mixture used contains some glycerine, or other liquid that keeps it soft and pliable; and after the cast has been taken the inner surface of this glue mold is washed with a solution of bichromate of potash, or formaline, to form a tough skin that will preserve it during future operations. Of course the original clay model is usually somewhat damaged during the above operations, but it is not entirely destroyed; and if the process of making the glue mold is successful a large number of plaster duplicates can be made from it. This casting of the figure in plaster is the final step in the sculptor's work, although he may have to do some touching up on the plaster cast before sending it to the metal founder; and occasionally it may be desirable also to do a little work on the cast metal figure; but if the founder is supplied with a suitable plaster model, and does his work skillfully, this is seldom necessary.

Throughout the history of its making a bronze statue is surrounded with interest, and everyone appreciates the lasting pleasure an artistic object of art in bronze gives to the public.

Photo by Press Illustrating Service, Inc.

In foreground is part of "Pan, the Spirit of Music," for Schealey Park.

Water Power in France.—In the French Alps the amount of energy developed by water now amounts to 738,000 horse-power, of which 40 per cent is used for lighting and power, 34 per cent in metallurgical processes and 20 per cent in electro-chemical processes. The great development which has taken place in the course of years is shown by a comparison of the preceding total horse-power with the state of affairs at the close of 1910, when the horse-power installed only reached 473,000. The number of works has grown in the same period from 126 to 205, those of a capacity exceeding 10,000 horse-power having risen from 13 to 28. There is a steady increase in the demand for power and the supply is fast becoming inadequate. —*The Engineer.*

Trees in Medicine*

Agencies for the Alleviation of Disease Provided By Nature

By John Foote, M.D., Associate Professor of Materia Medica and Therapeutics, Georgetown University, Washington, D. C.

THE idea that agencies of specific value in the alleviation and cure of disease are to be found in plants and herbs is one of the most deep-rooted, as well as one of the most ancient, of human beliefs. The remote folk-tales of archaic peoples embody this idea and relate its application by the hero, the magician or the priest. Even to-day we have our "herb doctors," and we do not need to go back much farther than a generation to recall the drug store, where large stores of "roots and herbs" were kept. There the apprentice was required to have sturdy shoulder-girdle muscles that he might turn the huge mill in which vegetable drugs were ground, or wield the pestle in the heavy iron mortar, where they were crushed, preparatory to being turned into decoctions, infusions, tinctures and other bulky preparations.

Nowadays we have more elegant, if less vigorous and copiously substantial, medicines prepared in the wholesale pharmaceutical laboratories. Gone is the drug mill, and it requires little muscles to serve soda water and perfumery. Gone, too, are many of the medicines from "roots and herbs" beloved of our fathers, but now shown to be valueless in the light of experimental pharmacology and our newer knowledge of pathology and bacteriology. For we have learned that medicines, except in a few instances, do not remove the cause of the disease, but may simply improve our natural resistance by aiding symptoms.

We have heard of "roots and herbs" in medicine, but, neither in ancient nor modern pharmacy, nor in household medicine, do the products of trees as medicinal agents elicit much comment.

And yet, in spite of the pharmaceutical image breakers and the therapeutic nihilists, some of the most valuable remedies used in medicine come from trees. And by trees is meant *trees*, not shrubs or bushes. One of the veritable Titans of the forest, a tree that has equaled the Big Trees of California in height, furnishes a much-used medicinal oil. And the one vegetable drug that is a specific for a certain disease, and cures by killing the blood parasite which causes malaria, was known to the older clinical teachers simply as "the bark," because it was the bark of a tree.

The place of trees and their products in medicine is far from being an incidental or an unimportant one, even in the most conservative works of the most advanced therapeutists.

And if, as has been asserted, the decadence of Rome was really due to malaria, and if her glory was obscured by a cloud of mosquitoes rather than by the dust of battles, then it may be that the possession of some cinchona and the planting of the eucalyptus in the Roman marshes might have prevented a great civilization from withering and fluttering away and changed the countenance of history.

But now to discuss some of the trees from which drugs and medicines are obtained:

The tallest tree known, the *Eucalyptus amygdalina*, is one of the many species of eucalyptus found in Australia. It has been known to reach a height of 480 feet. Its brother, the *Eucalyptus globulus*, which is the popular medicinal variety better known as the blue gum tree, is itself no dwarf, since it attains a height of 375 feet. It grows very rapidly, in almost any climate with a mean temperature of about 60 deg. Fahr., but does not endure temperature below 27 deg. Fahr., and is cultivated in the south of Europe, Algeria, India, Egypt, Natal and lower California. In the latter place it was extensively planted along the line of the Central Pacific Railroad. The large, dark green leaves contain a pungent volatile oil, with a characteristic odor, which is noticed wherever the trees grow. For a long time these trees were planted in malarious neighborhoods, in the belief that their aroma prevented the prevalence of malaria, but any such result as was obtained was probably due to the improved drainage in marshy localities, resulting from their rapid growth.

Oil of eucalyptus, distilled from the leaves, is an antiseptic and carminative. It is much used as an ingredient of antiseptic oil sprays in catarrhal diseases of the nose and throat, and is also used in tooth pastes, mouth washes, etc., when a mild aromatic antiseptic is desired.

Before the throat specialist uses the soothing oil application, he may employ a more stimulating one containing the oil of the pumilio pine. This has practically the same field of uses as eucalyptol. Various conifers, the *Pinus pinaster* in France, the Scotch pine (*Pinus sylvestris*), the swamp pine (*Pinus australis*), the loblolly (*Pinus tæda*), the long-leaved pine, southern yellow pine, Georgia pine (*Pinus palustris*), are sources of oil of turpentine and resin.

Oil of turpentine has some vogue as a counter-irritant in various liniments, and externally and locally in abdominal distention in typhoid fever and after abdominal operations. Resin enters into the composition of resin cerate and is the basis for some plasters. A derivative of turpentine is terpin hydrate, a drug of great popularity and considerable value in coughs and colds.

The beech (*Fagus sylvatica*, *Fagus Americana*, etc.), which is found in the temperate zone in Europe, America and Asia, is valuable in medicine for the creosote distilled from its tar. Creosote, creosote carbonate and guaiacol are medicines used to supplement the hygienic measures which have done so much to reduce the death rate in sufferers from pulmonary tuberculosis.

One of the most ancient medicines is nut-gall, a spherical body which is produced on certain species of oak by the irritation of insects in laying their eggs in the leaves of the trees. Pliny, Theophrastus and Dioscorides wrote of the medical uses of nut-galls. Hippocrates, as well as Pliny, recommended them for ulcerated gums, sore mouth and other conditions. The Somali women of Africa make a tatoo pigment from nut-galls. They have long been used to make ink, and are the principal source of medicinal tannic acid. When nut-galls or tannic acid are employed to-day they are used for the same astringent purposes for which they were recommended by the ancients. The galls are spherical bodies, 2-5 to 4-5 inch in diameter, and contain 27 per cent to 77 per cent querco-tannic acid. The *Quercus infectria*, of the Orient, furnishes most of the nut-galls, though the wood of all species of oak is also rich in tannic acid.

Whenever a pessimistic physician says that drugs never cure disease, some one is sure to ask him about quinine. For quinine is one of the few antiseptics which, taken internally, will kill an invading parasite without also killing the patient. Malaria is caused by a minute parasite injected into the blood through the bite of a mosquito. The parasite usually raises a new family every other day; hence the intermittent chills and fever. Quinine, taken in proper doses and at proper intervals, will kill this parasite and cure the disease by destroying its cause. It is, therefore, a specific drug. There are few specifics.

In 1632 the Governor of Peru was much worried about his wife, the Countess of Chinchon, who was desperately ill with chills and fever. The Corregidor of Loxa recommended the bark of a certain tree which the Indians used as a medicine. The medicine was given and the Countess recovered. The bark was then rewarded for its good behavior by being called Cinchona bark. The Jesuit order afterward introduced it into Europe, where it was called Jesuits' bark.

The *Cinchona calisaya*, *Cinchona succirubra* and other species of Cinchona are trees of various sizes, some reaching a height of 80 feet or upwards. Of the forty species, about a dozen are of economic use. They are native to New Grenada, Ecuador, Peru and Bolivia and grow in dense tropical forests, in isolation or in small clumps. The work of securing the bark is of great hardship to the Indian *cascadores*. Having found a tree, the *cascadore* must literally hack his way to it, clean it of surrounding vines, and brush and strip the bark from its trunk, later felling the tree and stripping the branches. The work of drying, packing and transporting this bark is done under equally adverse conditions, and the entire enterprise is difficult, dangerous and wasteful.

As early as 1854 the Dutch government endeavored to cultivate cinchona in Java. A successful industry was established in the East Indies in 1861. Now it is cultivated in Ceylon, southern India, British Burma and many similar tropical climes, and is an industry of great commercial value. Of the several alkaloids found in cinchona bark, quinine is the most important, medically and commercially.

Ask any physician, "What is the most useful and most used stimulant to the heart and nervous system?" and he will answer "Strychnia."

Strychnia is an alkaloid found originally in the seed of the *Strychnos nux-vomica*, the poison-nut tree, found in India, Burma and Siam, and growing also in Cochin China and Australia. It is of moderate size, and has a fruit the size of a small orange with a hard shell and a bitter pulp enclosing one to five seeds, less than one inch in diameter and one-fourth inch thick and shaped like disks. It is the bitterest substance known, and when one has heart failure, or nervous exhaustion, or is run down or needs a tonic, some doctor is sure to give him the alkaloid from one of these peculiar Indian trees. Textbooks on medicine frequently refer to "emergency heart stimulants," meaning by this drugs used by hypodermic injection to produce prompt stimulation of a weakened heart. Some of the most valuable heart stimulants require a good deal of time after being given to produce their effects, hence the need of emergency heart stimulants. Strychnine, we know, is a splendid emergency heart stimulant. But another one, hardly less valuable, is caffeine. Caffeine is a principle discovered in the coffee bean, which grows on a bush, not a tree—the *Caffea arabica*. Tea leaves contain a substance, identical with caffeine, called theine. The most important commercial sources of caffeine are tea leaves and the kola nut. The kola nut is the seed of the *Sterculia acuminata*, a tree found in Guinea, especially near the coast, and now cultivated in South America and the West Indies. It is a very important commercial product to the portion of Africa where it is found, because it is rich in caffeine and contains besides a somewhat similar substance called theobromine. For generations the natives have been accustomed, both in health and disease, to chew the kola nut as a stimulant.

Caffeine is a powerful drug, for it stimulates not only the heart, but also the depth of the respiration, the working power of the muscles, the excretory function of the kidneys, and is the one drug which will stimulate the thinking mechanism of the brain and increase the imagination. To the native of Guinea the kola nut corresponds to our morning tipple of coffee.

Another African tree which has various species—several hundred in fact—throughout the world, and is of some medical interest, is the Acacia. The *Acacia senegal* is the type of tree which furnishes gum acacia, or gum arabic. While acacia is not possessed of any marked curative properties of itself, it is a constituent of many important preparations in pharmacy, as, for instance, in the making of emulsions, where its heavy mucilaginous qualities make it a valuable vehicle for oily and resinous substances. It is also widely used in the preparation of pills and troches.

Gum catechu, a substance containing tannic acid and used in dyeing, which was at one time extensively used as a remedy in colitis and dysentery, comes from the *Acacia catchu* and *Acacia sumnis*, both native to India.

We know that the willow is useful for its timber, for basket-weaving, paper pulp, etc. The crack willow (*Salix fragilis*), the white willow (*Salix alta*), the weeping willow (*Salix Babylonica*), and many other species, are known. All are useful to produce medicinal charcoal and all contain salicin, a glucoside, and the forerunner of salicylate of soda, salol, aspirin, etc.—*almost* specifics for acute rheumatism and grippe, and among the most useful of modern therapeutic inventions. Although salicylic acid is made commercially from carbolic acid and soda, and the occurrence of salicin in the willow is, therefore, of more theoretical than practical interest nowadays, there exists a tree the oil from which contains an almost chemically pure salicylic compound, methyl salicylate. This has practically undeveloped possibilities as a source of chemically pure salicylic acid, when a product is wanted superior to that made synthetically. The bark of the black birch, *Betula lenta*, yields this oil in distillation. The birches grow extensively in Europe, Asia and America; they have practical use and may be cultivated in almost any northern climate. The relative cheapness of the synthetic acid has probably prevented the more extensive use of birch and wintergreen oils as sources of the salicylates. The old woods-

* *American Forestry.*

man's medical lore, which came to him from the savage, taught him to use these oils to cure "rheumatics." Here again, as in the case of cinchona, of nux-vomica, of kola and of coca, the scientist has builded his highway to medical knowledge on the trail blazed by the savage.

The citrus group, orange, lemon, etc., furnish us with citric acid, useful as a solvent and as a flavoring agent, while the almond furnishes a bland oil, and its cousin, the wild cherry (***Prunus serotina***), has a waning popularity as the base of a cough syrup. The antiquity of the almond is shown by allusions to it in the Old Testament. Aaron's rod was plucked from an almond tree.

Another ancient sacred tree is the sandalwood (***Santalum album***). References are made in the Chaldean inscriptions to this tree, and it is used in the sacred rites of the Buddhists. The oil has a limited use in medicine in certain catarrhal inflammations, and is employed in perfumery and sachets. It is found in India and the Pacific islands.

The pomegranate is a rather small tree, but has many claims to medical antiquity. The ***Punica granatum*** is found in India, Afghanistan and the regions south of the Caspian. It is mentioned in the Odyssey and in the Old Testament. The bark is used as a remedy for tapeworm and is very effectual.

The *Myroxylon pereiræ* is a lofty leguminous tree, growing in a limited area in San Salvador and Central America, and cultivated in Ceylon. Balsam of Peru, a viscid, aromatic balsam, used in surgical dressings and in perfume, is obtained from this tree. From its cousin, the *Myroxylon toluiferum*, comes balsam of tolu, once used in cough syrups. Another balsam, storax, employed as an insecticide, comes from an oriental tree, the ***Liquidambar Orientalis***, while the sweet gum of the United States (***Liquidambar styraciflua***), furnishes a resinous sap employed medicinally for catarrhal troubles.

A majestic tree that flourishes in the East Indies, the *Dryobalanops aromatica*, is the source of borneol or Borneo camphor. Japan, or ordinary camphor, is obtained from the *Cinnamomum camphora*, a tree flourishing in Japan, Central China and Formosa. The crude camphor is obtained by distillation of chips of wood, and is later refined by sublimation.

Camphor is a well-known household remedy for external application. Internally it is of value in ordinary colds, coryza, and as a diffusable heart and circulatory stimulant.

Quassia, the bark of the ***Quassia amara***, a South American shrub, named after its discoverer, the negro Quassin, who used it in fevers, is now largely replaced by so-called quassia *wood*, which is really the wood of the ***Picræna excelsa***, or bitter ash, a tree found in Jamaica. It attains a height of 50 feet. It has little value in fever, but is a bitter tonic, and its infusion is used to kill intestinal parasites.

Cinnamon, used more as a flavor than as a medicinal agent, is the bark of a tree, the *Cinnamomum Zeylanicum*, found in Ceylon. Benzoin, a gum-resin, used in medicine as an inhalant, and containing vanillin and benzoic acid, is obtained by incising the bark of the *Styrax benzoin*, a tree of considerable size, native of Sumatra and Java.

Resin of guaiac, used in gout, rheumatism and sore throat, is obtained from the heartwood of the ***Guaiacum officinale***, or *Lignum vitæ*, a native of the West Indies and the north coasts of South America, which grows to a height of 20 or 30 feet. One of the most useful and delicate tests for the identification of blood is performed with the aid of an alcoholic solution of guaiac.

Myrrh, with gold and frankincense, was brought as a gift to the Messiah by the Magi. It was valued by the ancients as a perfume, and was used by the Egyptians in embalming. Myrrh is a gum-resin, a product of the ***Balsamodendron Myrrh***, a small tree which grows in Eastern Africa and Arabia. It is little used in medicine nowadays, except as an application in certain conditions of the gums. A curious survival is the ancient custom, dating back at least to the time of Edward I, of presenting to the King of England on the feast of the Epiphany, gold, frankincense and myrrh, the ceremony taking place in the Chapel Royal.

These are some of the medicinal uses of substances obtained from trees. Much remains to be done in the cultivation and conservation of medicine-bearing trees, for there are many species whose existence is threatened by the present hap-hazard and wasteful methods of obtaining their products.

How to Silver Mirrors for a Reflecting Telescope

By John E. Mellish

There are several methods of silvering mirrors for reflecting telescopes which yield nearly the same results. The formula given here is the one which is most generally used, and which seems to give the best results. I shall describe the silvering of a 6-inch speculum first, as that is a very suitable size for experiments.

The following chemicals are required: Caustic potash (potassium hydroxide, purified by alcohol), silver nitrate, aqua ammonia, nitric acid, alcohol (pure grain), pure loaf sugar, and distilled or rain water. For holding and mixing the chemicals, use glass, earthenware, porcelain, or other glazed dishes that nitric acid will not attack, or, if such dishes are not at hand of a suitable size, wood or cardboard boxes can be used if they are carefully covered with paraffine wax, which is acid-proof.

The first solution to be made up is the reducing solution, which is to be kept in stock, and works better after standing some time. This solution, D, consists of the following constituents in the proportions given: Loaf sugar, 840 grains; nitric acid, 40 grains; alcohol, 3 ounces; distilled water, 1 ounce. Mix thoroughly, and make up into 25 ounces with distilled water, and bottle. When ready to silver, make the following solutions: A, distilled water, 2 ounces; silver nitrate, 50 grains; and B, caustic potash, 50 grains; distilled water, 2 ounces.

Cement the glass to a strip of wood and hang face down in one of the dishes, and pour distilled water in until it covers the face of the speculum; then take a piece of clean white cloth or a ball of cotton on the end of a glass rod, and with nitric acid clean the face and sides of the speculum until there is no trace of grease or other matter, for the silvering cannot be well done unless the surface is perfectly clean. Immerse the face of the speculum into the water, and remove and examine the face. If it is covered with an unbroken film of water it is chemically clean; if the surface is dry in places, as is most likely, the scrubbing with acid must be repeated until the surface is fully covered with an unbroken film of water. Then put the speculum back into the water and leave until the solutions are mixed.

Put aside one-tenth (1/10) of solution A, and pour the remaining nine-tenths (9/10) into a glass, and add strong aqua ammonia (solution C), drop by drop, until the solution is perfectly clear. With the first drop of ammonia the solution should turn milky-brownish, and with each succeeding drop it will grow darker brown; when transparent, no more aqua ammonia should be added than is necessary to clear the solution, or else the silver film will tarnish rapidly. If the solution does not darken with the first drop of aqua ammonia, something is wrong. There are impurities in it, and everything must be examined. First, make sure that the chemicals are bought from a reliable druggist; then there is not much danger of the chemicals being impure. The dishes and everything containing the water and chemicals must be clean. Before mixing the chemicals the dishes ought to be well cleared with nitric acid.

Solution A being clear, add solution B, and A will at once turn dark. Add aqua ammonia drop by drop until the solution is clear. Frequently the solutions will contain dark particles after being cleared with aqua ammonia. These are the result of impurities and should not be present, but they cannot always be removed. After the solution is clear again, take the one tenth of solution A that was set aside and add it drop by drop until the foregoing mixture is tinted saffron or straw color; but care must be taken not to add enough to destroy the transparency of the solution, or it will not work well. It should be sufficiently transparent so that one can see distinctly through four inches of it. Sometimes so much aqua ammonia has been added that the one tenth will not bring the mixture to the required tint. In this event, a little extra water and silver nitrate are to be mixed and added until the mixture is of the right tint. Now add one half ounce of solution D, and stir with the glass rod until the mixture becomes black. Have enough distilled water set aside beforehand so that when this solution turns dark the water can be added and the solution poured into the dish in which the silvering is to be done, and there will be enough, so that when the glass is quickly transferred from the other dish the solution will be about one quarter inch above the face of the speculum. Always immerse the speculum sideways to avoid air bubbles. The bath will turn brown, and within a period of a few seconds to two or three minutes the silver should be visible on the under side of the glass. The glass can be gently rocked until the bath is muddy, when the silver is all deposited.

The glass must then be removed and washed with tap or well water and finished with distilled water and set on edge to dry. The silvered surface must not be touched with anything until perfectly dry, when it can be polished with a piece of fine chamois skin touched with fine jeweller's rouge. The polishing being done with a light circular stroke, the temperature of the room should be about 80 deg. Fahr.; if cooler, the film is likely to be soft, and will not polish readily without scratching. The silver film is best if the glass is taken out of the bath before it becomes muddy. The film is then frequently so pure that it cannot be improved by polishing. The film of silver need not be so thick that one cannot see through it; the very best film is just dark enough so that the buildings or trees show through it without much detail. A thicker film will not reflect one per cent more light, and is likely to be drawn uneven, destroying the beautiful optical surface.

My first parabolic six-inch speculum was a sphere before it was silvered. It had a very thick coat of silver, 200 grains being used. It was polished with chamois skin and rouge at the center until it was a perfect paraboloid under test.

The small diagonal mirrors are the hardest to silver. They are best silvered by laying them in a shallow dish face up and covering with acid, then scrubbing the face with cloth or cotton until the acid covers the surface in an unbroken film, when the acid is turned off and the glass cleaned from acid by washing with ordinary, then distilled, water. Next, the glass is put into a deep dish just large enough for the glass to lie in the bottom, face up, and the solution poured in and shaken violently until it turns muddy, when water is to be turned in and the glass washed.

Specula may be silvered by wrapping a band of paper soaked in melted paraffine wax around the speculum and tying tightly. The surface is cleaned with acid and covered with warm distilled water, and the silvering solution mixed and stirred until the silver starts to deposit, when the solution is poured upon the face of the speculum, which is rocked rapidly to keep the solution in motion. When the solution changes to brown or the silver is thick enough, water is added, and the surface washed as before.

The mirror must be warm to silver with the best results, face up. If the silver film is not good, it is best to remove it with acid and cover the surface with distilled water, and mix another batch and try again.

Rainwater is just as good as distilled water if it is caught in the open in clean dishes. It can be bottled and kept, and works better after standing for months. It is best for one to get a pair of scales that weigh from one grain to two or three ounces, and do all his own weighing; and for the first experimenting it is well to use a small amount of solution and try silvering a small piece of glass. If very strong aqua ammonia is obtained, it is better to mix it with water to reduce its strength, as it acts too rapidly when very strong.

The best way to treat the silvered surface is to let it stand twenty-four hours before polishing. The silver hardens, and will not scratch so readily. Place the mirror in front of a window where the sun will shine on the surface for an hour; then heat the chamois skin to make sure it is perfectly dry, and polish. If the mirror is to be used immediately after silvering, it can be held over a stove, radiator, or lamp; heat dries the film, so that it can be polished without danger of scratching.

If a mirror becomes damp while using, it can be taken out and held over a lamp and dried. One advantage a reflector has over a refractor is that the speculum is in the closed end of the tube, which then acts as a long dew cap. I have used reflectors all night in the open with no trouble from dewing of the speculum.

The objective of a refractor would dew over in a short time, and the diagonal of the reflector (with twelve inches of the tube projecting out like a dew-cap) would dew over every two or three hours. I would take it out, hold it over a lamp, and in five minutes it would be back in the tube and ready for use. Warming it destroys definition for a few minutes, but this is far better than having to stop observing. There are not many nights in a year when the diagonal dews over in this way. Generally, after being used all night, it looks a bit dull by morning. If there is a breeze, it never dews over. When the silver film is damp, it must never be touched, or the silver will peel off.—*From the Monthly Register of the Society of Practical Astronomy.*

Tests show that the strength of splices in medium and hard-drawn copper is liable to depend on the temperature at which the soldering has been done.

Cyclonic Disturbances and Their Effect

An Explanation of the Air Currents Involved

Cyclonic disturbances, variously known as hurricanes, typhoons, cyclones, etc., each year leave in their path lasting impressions of their devastating force. Scarcely had the wreck of the naval collier "Hector," on July 14th, 1916, been chronicled when another and greater disaster befell the armored cruiser "Memphis" in the harbor of Santo Domingo, on August 29th, 1916. Both vessels met destruction in the teeth of unleashed tropical hurricanes.

The former vessel, the collier, was caught off the coast of South Carolina. Huge waves broke over her, pouring hundreds of tons of water down her hatches, flooding her hold and completely disabling her engines. Helpless, and at the mercy of the gale, she was picked up and thrown on the shores of Cape Romain, where the gigantic pounding of the breakers soon broke her back and left her a total loss. A month and a half later another tropical hurricane sprang up in the West Indies and swept over Santo Domingo. In the harbor of Santo Domingo City lay the 14,000-ton armored cruiser "Memphis" (formerly the "Tennessee"). This storm caught the large cruiser at her moorings in eight fathoms of water, where the gigantic rollers, driven before the hurricane, alternately tossed the cruiser first high on their crest and then violently sent her smashing into their deep trough, where her draft exceeded the depth of the water. Before the moorings could be slipped and the harbor cleared, the terrific pounding sprung the bottom plates and burst the main steam line from the boilers to the engines, fatally scalding firemen and engineers. Pitifully helpless, the cruiser soon tore away from her moorings and was sent crashing over jagged pinnacles to within fifty feet of the rocky cliffs in front of the city. To-day this ill-fated vessel is a most awe inspiring picture of the havoc the unfettered forces of nature can produce.

The study of cyclonic disturbances has been and is still most ardently pursued the world over, and especially in this country by the United States Weather Bureau. The most valuable instrument in foretelling the existence and approach of cyclonic storms is the mercurial barometer, an instrument in which the weight of a column of air of given cross sectional area is balanced against that of a column of mercury having an equal cross sectional area. The pressure of the atmosphere is measured in inches instead of pounds; i. e., the pressure of the atmosphere is a certain number of pounds to the square inch and is equivalent to the pressure produced by a column of mercury of so many inches. This system of measuring atmospheric pressures in inches of mercury has been adopted mainly on account of the ease in so recording the ever-changing height of the barometric column.

Variations in atmospheric pressure over the earth's surface are produced by differences in temperatures. Air, although extremely light, has a definite weight, which at the sea level approximates fifteen pounds to the square inch (thirty inches of mercury). Supposing now that the atmosphere over any considerable portion of the earth's surface is heated to a higher degree than that of the surrounding portions, this heated air will expand, and its upper layers will flow off to the surrounding regions. This condition will decrease the density of the air throughout the heated portion and in consequence the barometric column of mercury will stand lower than a column of mercury in the surrounding cooler area. As a result of this difference in pressure, a current of air is set up, flowing along the surface from the area of high pressure to that of low pressure. The velocity of this current of air, as well as its direction, depends upon the relative pressures in adjoining areas; being determined by the steepness of the barometric gradient for a given distance. Gradients or differences in pressure are commonly reduced to hundredths of an inch per fifteen sea miles. On this basis one of the steepest gradients ever observed was in the cyclone that passed over False Point, India, in September, 1885. This gradient was 238, i. e., in a distance of 15 miles there existed a difference of barometric pressure of 2.38 inches.

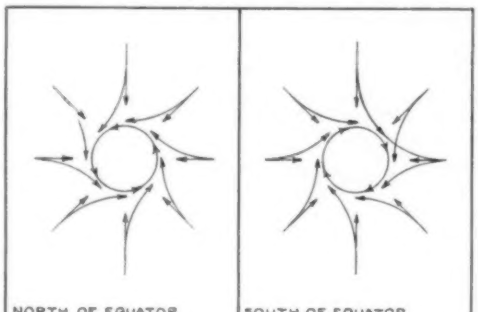


Fig. 1.

Over the earth's surface the air lies in five broad belts as regards to prevailing pressures. Near and around the poles and over the equatorial region low pressures exist, while in the neighborhood of 30 deg. Lat. a belt of high pressure is generally found. This belt of high pressure, while not always well marked over large land areas, can be clearly traced over the ocean, where it is known to mariners as the "Horse Latitudes," while the stagnant, torpid, equatorial hot belt is known to them as the "Doldrums."

As a result of the distribution of pressures just described, there is in either hemisphere a continual motion of the surface air away from the high belt—on one side toward the equator, on the other side toward the pole. In the first case the prevailing winds thus set up are called "Trades," while in the second case they are callerd "Westerlies." If the earth were stationary these winds, unaffected by barometric gradients, would follow the meridians, but owing to the rapid rotation of the earth upon its axis, they are materially influenced, and in consequence deflected from their normal path. This deflection being to the right in the northern hemisphere and to the left in the southern. This deflection becomes clear from the following:

As the earth revolves from west to east, the envelope of air surrounding it shares its motion. Thus a body of air moving from some point in high latitude toward the equator will at the start have an eastward velocity equal to that portion of the earth's surface from which it starts, but as the body moves toward the equator it will find the earth beneath it turning more and more rapidly (linear velocity) and, failing to take up entirely this increased velocity, will lag behind and will manifest itself as a wind from the north and east in the northern hemisphere and as a wind from the south and east in the southern hemisphere.

A similar body of air moving from the equator toward higher latitudes starts out with the eastward velocity of the earth at the equator and will thus outrun the more slowly moving surface over which it passes as it moves toward higher latitudes, and will manifest itself as a wind from the south and west in the northern hemisphere and as a wind from north and west in the southern hemisphere.

The condition of affairs just described is graphically shown in Fig. 1, and accounts for the characteristic circular motion of the indrawing air of cyclonic disturbances. By referring to the sketch it is readily seen that in the northern hemisphere the cyclonic motion is in a direction opposed to the hands of a watch and with the hands in the southern hemisphere. Cyclonic storms are broadly divided in two classes, viz., tropical, or those which originate near but not on the equator, and extra tropical, or those which first appear in higher latitudes. In general the characteristics of both are similar except that those of the former are more violent and of greater destructive force. For the purpose of this article our attention is mainly confined to the cyclonic disturbances originating in the tropics.

The occurrence of these cyclonic storms is confined to the summer and autumn months of the respective hemispheres and to the western part of the several oceans, the North Atlantic, the North Pacific, the South Pacific and the Indian Oceans. They are unknown in the South Atlantic. Although these storms are of the same essential characteristics, they have been generally called hurricanes when occurring in the West Indies and the regions between Samoa and Australia, typhoons when occurring in the regions of the Philippines and China Sea, and cyclones when occurring in the Indian Ocean and its dependent seas.

The yearly average number of those occurring in the West Indies is four, in the Philippines twenty-one, in the Bay of Bengal nine, in the Indian Ocean and in the regions between Samoa and Australia four.

Many theories have been put forward to explain their origin, none of which is entirely satisfactory. However, they originate over the ocean between the equatorial hot belt and the trade wind regions. Here unsettled conditions of barometric pressure prevail and the generally accepted theory connects the development of the disturbance with the existence of a preliminary abnormal sultry, rainy and squally condition in the lower strata of the atmosphere with a coincidence of abnormal low temperatures in the upper strata. These conditions produce a violent upper draft in the lower layers of the heated and saturated air, and consequently result in the further lowering of the already existing low barometric pressures in this locality. A general overturning of the atmosphere occurs, violent inrushes of the air from surrounding areas of high pressure take place, increasing in intensity by the formation of clouds and rain in the ascending currents of air, which in their liberation of latent heat act to still further accelerate the violence of the upward and inward rushing currents. The indrawing currents as previously explained take up the characteristic cyclonic rotation. A vortex called "the eye of the storm," is soon established and in this area of small diameter a partial vacuum exists. Around this vortex the air swirls at varying rates and the storm as a whole takes up a motion of translation following the trough of low barometric pressures. The direction of this translation is in general away from the tropics and to the westward until the elastic yet impenetrable barrier of higher pressure is encountered which causes the storm to curve off into higher latitudes and to eastward. Figs. 2 and

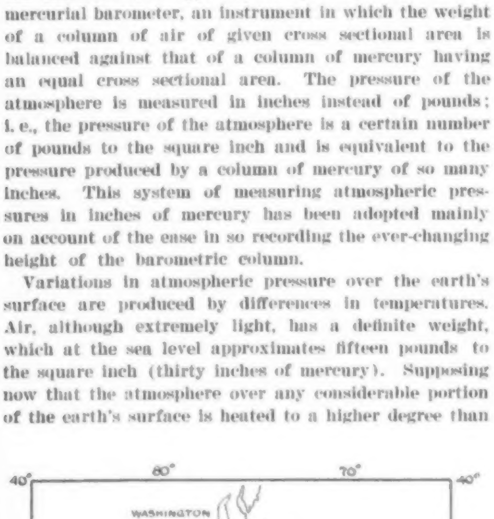


Fig. 2.

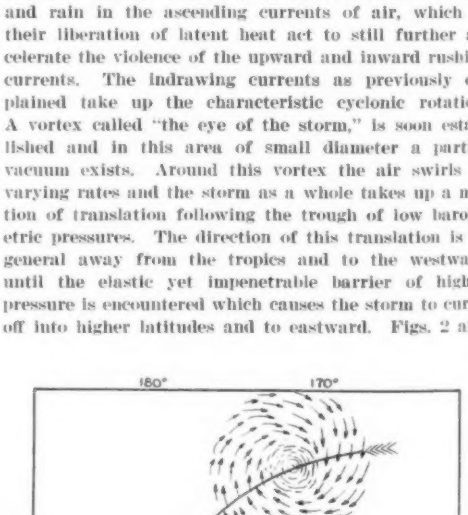


Fig. 3.

3 show respectively the path and rotation of characteristic cyclonic storms occurring in both hemispheres.

In the early stages of cyclonic storms they are of small area but great intensity. As they progress they spread out in area and diminish in intensity. The velocity of rotation is greatest when the eye of the storm is small and well defined, attaining at times a rate in excess of 100 miles per hour. The velocity of translation varies from a few miles to approximately 40 miles per hour, depending greatly upon the barometric gradients over which the storms pass.

Generally the hurricanes of the West Indies sweeping westward over Florida skirt the coast of the United States to Cape Hatteras and then shoot out across the Atlantic where they finally break up into southeasterly gales. A notable exception in this general sweep of the West Indian hurricane occurred when the hurricane of September, 1900, found the path of previous hurricanes blocked by a mantle of high pressure hanging over the eastern coast of the United States and far out into the Atlantic. This storm shunted into the trough of low pressure lying over the Gulf of Mexico, broke over the city of Galveston, wiping out 6,000 lives and destroing $30,000,000 in property before it passed on.

The earliest indications heralding the still distant cyclonic storm usually result in an abnormal rise of the barometer, with cool, dry, fresh winds and cessation or complete reversal of the land and sea breezes and with a very transparent atmosphere; also in the heavens will be seen light feathery plumes of the high cirrus clouds radiating from a point in the horizon marking the storm's center. At sea, a long, low swell with occasional high hurricane rollers is sometimes noticed. These waves outrun the storm by hundreds of miles and when no intervening island or coast line affects them, their direction indicates the bearing of the center of the storm. As the storm draws nearer the sky becomes hazy with a thin uniform cirrus veil, halos are noticed by day and night, the barometer begins to fall, and later becomes unsteady, the air becomes heavy, hot and moist, red and violet tints are seen at dawn and at sunset, fine misty rain falls, and at last the low, rugged-looking cloudbank of the hurricane appears on the horizon, which at sea looks like distant land.

The storm wave or general rise of the level of the sea near the eye or center of the storm, due to the inrushing winds of low pressure, sweeps along with the storm, sometimes precipitating devastating floods upon islands and coasts in its path. These floods are often spoken of as tidal waves, and such a flood on the night of October 31st, 1876, in the lowlands of the Ganges delta drowned 100,000 people and resulted in the death of as many more through famine and disease.

The Dynamographic Platform

A Device for Teaching War Cripples to Walk

The surgeons and physicians of Europe are making heroic efforts at the salvage of the human scrap-heap created by the war. Instead of herding cripples in Soldiers' Homes or equipping them with a peg leg, a fiddle and a tin cup to gather coins from compassionate passers-by, the modern idea is to provide them with artificial limbs or prothetic appliances and then give them such physical and industrial training as will fit them to enter once more the arena of active life. This re-education of cripples is based on scientific lines.

The first step is to study the results of the injury so as to determine just how much strength and capacity of motion remains in the "stump" of a limb which has had a portion of it amputated. Next comes the fitting of the stump with the required artificial appliance, and finally the re-education of the member. A French scientist has facilitated this work as far as regards the leg, by an ingenious device known as the "dynamographic sidewalk." The inventor, M. Jules Amar, the author of a book entitled "The Physiological Organization of Work," was engaged with two problems: the study of the pathological gait of cripples and the best methods of re-education to approximate normality, and also the determination of the absolute merits and demerits of the numerous artificial legs offered to the French *Service de Santé*, so as not to leave the question open to discussion. Since the eccentricities of a pathological manner of walking can be fully recognized only when compared with the normal gait, M. Amar conceived the idea of making "a double dynamographic sidewalk" which should register the phases of movement of a sound leg on the one hand, and on the other those of an artificial leg or injured one. This "sidewalk," which has been in operation for about a year, was thus described at a recent meeting of the Academy of Sciences, as reported in the *Comptes Rendus* (Paris) for July 31.

"The dynamographic *trottoir* is composed of two wooden platforms or planks, parallel and similar, each covering the same kind of mechanical registration device enclosed in a wooden case. At each end are stationary steps for getting on and off. The dimensions are as follows: length, 3 meters (about 10 feet); total width, 0.5 meter (about 20 inches); height, 0.3 meter (about 12 inches). The mechanical device is composed of levers of wrought iron, having a section of 40 millimeters by 10 millimeters (1.56 inches by 0.39 inch). These are placed in pairs in the box and cross in the middle. Each lever is attached at one side by a pulley (*articulation à chape*), and on the other is in contact with a flat spring which rests on the opposite lever. Eight springs act in the same way in the interior of the *trottoir*, four for each platform, symmetrically placed. At the points where they cross the levers are tangent to a small pear-shaped bulb of rubber, *A*, *E*, *I*, and *V*, connected with a recording diaphragm. The springs have a force of 20 kilogrammes for a compression of 10 millimeters (0.39 inch). The vertical steel supports, 30 millimeters by 8 millimeters (1.17 inches by 0.312 inch) are braced to the levers and sustain the sidewalk. This is completely mobile in its horizontal plane, because of its mode of suspension. It is, in fact, supported by an articulated system which assures its displacement, not only longitudinal, but lateral, in both directions. And in these three different displacements it encounters the small rubber bulbs for the registration.

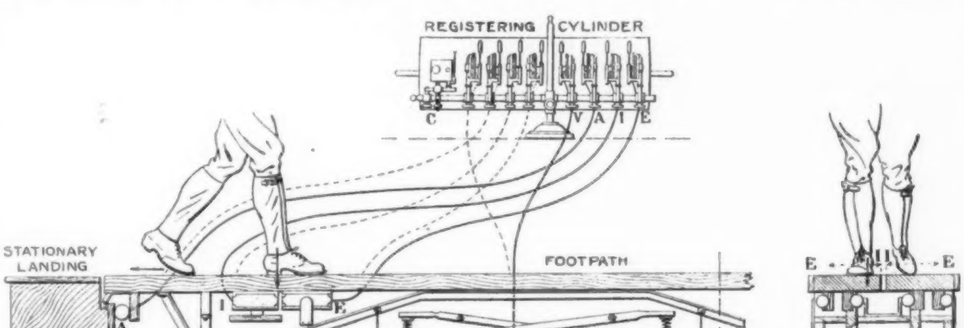
"The resistance of this device is guaranteed against all excessive bending by T-iron braces which run along the internal surface of the sidewalk; they have a section of 50 millimeters by 30 millimeters (1.95 inches by 1.17 inches) and occupy the entire length of the chest. A turnbuckle, fastened by movable bolts, consolidates them below (see illustration).

"The movements and forces registered are therefore eight in number, four for each leg: the vertical pressure, the backward impulsion of the leg which leaves the sidewalk, and the internal and external lateral thrusts of the foot. By means of rubber tubes these pressures are transmitted to registering diaphragms placed in front of a rapidly rotating cylinder, operated by gravity."

By means of this apparatus, says M. Amar, a remarkably clear tracing of each type of gait is obtained, since it is adjusted to the proper degree of sensitiveness. It is also very reliable and accurately represents the gait of a man walking on an ordinary sidewalk. The author sums up its advantages in these words:

"The inscription of the time completes this physiological analysis. To accomplish the locomotor re-education of the wounded, to correct bad methods of walking, to establish the diagnosis of degrees of weakness and follow their development—these constitute one object of the dynamographic *trottoir*. But there is a second object still more important: i. e., the control of the faults which prothetic apparatus occasion in the execution of the step, and which sometimes react unfavorably on the functional condition of the stump."

We learn from another source that M. Amar is the director of the "Laboratory of Military Prothesis and Professional Labor" at the Conservatoire des Arts-et-Métiers in Paris, and that he has made extensive studies in this capacity of the alteration in nervous sensitiveness and in muscular force of the stump of amputated limbs. It is on these researches that he has based his system of "re-education" of cripples so as to regain both nervous and muscular control of such portions of the legs or arms as remain to them after operation.



Sectional elevation and cross section of the dynamographic platform.

The Preparation of the Knife for Section Cutting

Cutting sections by means of a hand microtome can never be a theoretical success, on account of the number of possible and probable errors we always encounter. All these errors can be minimized by care, and as a result hand section cutting is the best method we know of at the present time for some materials. The most likely error is in the knife rocking when passing through the section; this can be avoided by having the microtome top perfectly level and the knife cutting edge and back both in the same plane. The microtome top is not difficult to keep straight by the following means: Take a piece of plate glass and put on it a mixture of water and brass finishers' sand, keep it in a sloppy condition, and rub the microtome top backward and forward until the top has a good bearing surface and is level. On no account use emery powder, as the emery particles embed themselves in the glass table and will afterward spoil the knife.

To straighten the knife the same plate of glass can be used, but very fine carborundum powder or emery in place of the brass finishers' sand on account of its quicker cut. If the knife is twisted, grind the back of the blade on an emery wheel until the twist is taken out; if twist is once taken out it should always remain straight.

When sharpening a knife it is rubbed away more at the center of the blade than at the ends, so it is necessary from time to time, when the blade gets hollow, to rub it on the glass plate to make level.

In sharpening use a whetstone of good quality and as broad as the knife blade is long, if you can get it, and keep the stone level by rubbing it on the glass plate with emery and water. After flooding the stone with water or oil, place the knife flat on it and rub the knife away from you with the back nearest to you and the edge away, that is, the edge first in the direction of travel, until you get to the end of the stone; then turn the knife over on the other side of the blade, this time the back away and the cutting edge toward you, and draw the blade along the stone toward you until you get to the other end of the stone. Remember always to keep the cutting edge in front whichever way you rub. Keep the stone covered with water or oil and a sharp edge should be obtained.

For stropping use a strop fastened to a flat board, and work the knife as a barber does when sharpening a razor.—*From the Transactions of the Manchester Microscopical Society.*

Detection of Tallow and Hydrogenated Fats in Butter Fat

The method depends upon the different solubility in ether of the glycerides of butter fat and of fats containing tristearin or β-palmitodistearin. Thirty-one grammes of the clear melted fat at 40 to 50 deg. Cent. is placed in a warm 400 cubic centimeter flask, which is then filled with ether, closed with a cork, shaken vigorously, and placed in a water bath. After one hour it is again shaken, replaced in the water bath for another hour, and shaken again. If there is no appreciable precipitate the butter fat contains less than 12 per cent of tallow or the like. If a precipitate is present, it is collected on a filter, washed with 3 to 4 cubic centimeters of ether containing 20 per cent of alcohol, and weighed; if the weight amounts to 0.4 gramme or more the butter fat is adulterated with a considerable proportion (15 per cent or more) of tallow or the like.—*Note in J. Chem. Ind. from an article by K. Arnberger in Z. Unters. Nahr., Genussm.*

Refractory Materials—I*

Their Characteristics, Applications and Methods of Examination

The Faraday Society has opened the new session by one of the useful and much appreciated general discussions in which the society excels. The subject, "Refractory Materials," is one which equally concerns the engineer, the metallurgist, the chemist, all interested in keramics, and the general public.

In his introductory remarks the President, Sir Robert Hadfield, F.R.S., pointed out that, although the correct kind of refractories was of importance for the satisfactory working of steel furnaces and metallurgical operations generally, the subject had not altogether received in this country the attention it deserved. There were about 200 makers in Great Britain—140 in England, 40 in Scotland, 30 in Wales—notably in Stourbridge, the Sheffield district, Scotland (Eglinton and other places) and South Wales. Lecturing on "Refractory Materials and the War," before the Society of Arts, in January, 1915, Dr. A. B. Searle had stated that the manufacture of chemical porcelain was almost unknown in Great Britain, and that the British firebricks did not satisfy the tests of Continental coke-oven builders. The work done since by Prof. Henry Jackson, and others in the London and Sheffield Universities had altered conditions, however, Sir Robert remarked. Refractories had largely been imported, though our own country possessed equally good, if not better, material; his own firm could plead guilty to having purchased material from abroad which was really near at hand. The first large-scale development of the Bessemer process had taken place in Sheffield because the Sheffield ganister (95 per cent of silica, 2 of alumina, 1 of lime, etc.) had proved a particularly good lining material for the converters, as it had been recognized—and was still unsurpassed—as the best lining for the pot-holes in which Sheffield crucible steel was made. Quoting at some length from the "Standard Specifications for Refractory Materials" drawn up on behalf of the Institution of Gas Engineers in 1912 by Dr. H. G. Colman, of London, and Dr. J. W. Mellor, principal of the Staffordshire County Pottery Laboratory, and from a paper read before the same institution by Mr. F. J. Bywater (now on active service), Sir Robert stated that according to the researches of Bischof, Richters, Seger and others, pure silica had a melting-point of 3,326 deg. Fahr., pure clay a slightly higher melting-point, and that of mixtures of the two materials the mixture $SiO_2 2Al_2O_3$ was the most refractory. The position of a clay in the scale of refractoriness, however, also depended upon the amount of flux present, iron oxide, lime, magnesia, potash, soda; these fluxes seemed to act in the ratio of their equivalents, *i.e.*, 20 parts of MgO had the same effect as 28 parts of CaO, the ratio of the combining weights being 40 : 56 = 20 : 28. Thus the ultimate analysis of a refractory was often of little use, unless preceded by mechanical or other methods of subdividing the material into its mineralogical constituents, and furnace tests should be applied to mixtures. The Armstrong Cork and Insulating Company, of Pittsburgh, was using a ready test by letting a very hot flame (Bunsen burner) play upon the surface of a brick, which was held in the hand until it became too hot; we should think that a man performing this test often would finally pass almost any of these diatomaceous bricks, for which remarkable heat insulation is claimed.

Sir R. Hadfield then passed to other refractories, especially to zirconia, quoting from S. I. Levy's book on "The Rare Earths," Riecke, Conrad Meyer, Percy's "Metallurgy," Kohn on "Moulding Sands," Roberts-Austen's "Introduction to the Study of Metallurgy," and other authorities. As a metallurgist, Sir Robert distinguished acid refractories (dinas rock, ganister, fireclays), basic (dolomite, magnesite), and neutral refractories (bauxite, chrome, iron ore, graphite and a few fireclays). The success of an acid or basic steel process depended upon the acid or basic lining; neutral linings possessed great advantages, but were generally very expensive and difficult to apply: electric furnaces might be given acid linings, but basic, neutral or zircona linings yielded much better results. For Sheffield crucible steel there was still only choice of two materials: pot clay, a mixture of fireclay, China clay, a little carbon and sometimes small quantities of special materials, the usual mixture being two-thirds raw clay and one-third burnt clay; and plumbago crucibles, fireclay and plumbago suitably mixed. The objection to this latter material was that carbonization of the melting steel took place, while the ordinary Sheffield crucible, used since the days of Huntsman, gave a uniform steel; that was the open secret of the uniformity of Sheffield crucible steel. Howe had also used blocks of millstone grit from the Sheffield moors, with fair results.

With regard to his own exhibits, Sir Robert remarked that sand for open-hearth bottoms had almost entirely been supplied by Belgium, but some British sand, first used mixed with Belgian sand after the outbreak of the war, gave practically the same results. "Half-baked" silica bricks often caused serious troubles. Fireclay nozzles were attacked by manganese steel, which did not attack magnesite nozzles; the latter were more used now. The nozzles exhibited to illustrate this superiority of magnesite nozzles, which was pointed out for the first time, were most striking. Sir Robert had tried a combination of fireclay and magnesite for nozzles, but it had not answered. Fireclay nozzles wore badly; fireclay stoppers in magnesite nozzles were apt to collapse during casting; magnesite stoppers, so far, were not a success, as they were liable to crack and spelch. Plumbago nozzles and stoppers had not proved any better in his experiments than fireclay products. Dolomite bricks would be invaluable for the roof and walls of electric furnaces if means could be devised to prevent perishing.

Dr. J. W. Mellor followed with a paper on "The Texture of Firebricks," which was one of the most important questions to be considered, he stated, since the life and character of a firebrick were largely determined by its texture. The texture varied from the porous texture of bricks for boiler insulation to that of the non-porous and vitreous materials for crucibles and acid-resisting bricks. In the specimens which Dr. Mellor exhibited the bricks had been cut transversely, and the exposed surface had been polished and photographed; glass plate had then been cemented to the polished face (by means of Canada balsam); the method was due to Mr. Lomax; the specimens illustrated a great variety of British (and also German) bricks and experimental results. The more important mineral constituents of clays, Dr. Mellor continued, were the granular feldspathic or micaceous fluxes, granules of clay proper, and quartz grains. Virtually, Nature might be said to have made all fireclays by mixing these three components with accidental and often deleterious impurities—schorl, pyrites, siderite, etc. The osmose process of clay purification removed these impurities, but slipping and lawning the weathered clay should first be applied; either process improved the clay, but ran up the cost, of course. In the kilns the fluxes begun to melt at 900 or 1,000 deg. Cent. and to attack the grains of quartz and dry clay; at higher temperatures clay and quartz reacted on one another, and either might be considered the flux. The fluxing action was necessary to bind the brick to a compact whole of mechanical strength able to withstand also abrasion and attack by flue dust, slags, etc.; the fluxing was a time action and long heating at low temperature would, apart from secondary effects, produce the same contraction as short heating at high temperature.

When the size of grain was reduced, the number of grains increased enormously. If a clay contained 720 grains of 1 millimeter diameter per gramme, there would be 720,000,000,000,000 grains of 0.0001 millimeters. On the same reduction of size the surface area would increase from 22.6 to 226,415 square centimeters. The grains were not spherical, of course, nor regular, but angular, and that was desirable; round quartz grains were not firmly embedded in the matrix. Pressure lowered the softening temperature; according to recent experiments by Drs. Mellor and B. J. Moore the squatting temperature was given by $Ce=kP$, where C was the squatting temperature of the clay under no load, P the load in pound per square centimeter, e the logarithmic base, and k a constant of the order of 0.001, generally much smaller for siliceous than for aluminous clays, however. As anything favoring vitrification would reduce the refractoriness, the coarser grain and texture would be less liable to soften. This was very noticeable with fluxes of clay and fine-grained silica, which spoiled a brick, while coarse-grained silica improved the refractoriness. With gradual heating the surfaces of the more fusible granules melted first, and for that reason again refractory bricks should be coarse-grained.

Proceeding, Dr. Mellor said that he had called the changes occurring during the firing of a refractory *arrested reactions.* The fluxes melted, and dissolved and bound the other material, and there was a certain amount of contraction which, if not completed, went on afterward in the used brick. A few years ago that *after-contraction*, for which bricks were tested to specification, had amounted to 2 or 3 per cent; now it was reduced to 1 or ½ per cent, but it was usually impracticable to suppress it altogether, even if the bricks were fired a dozen times. With silica bricks there was generally an *after-expansion*, due to the change of quartzose silica (density 2.65) to a lighter silica (2.3). Quartzose also occurred in clays, and fluxes also expanded during firing by 6 per cent; while clay contracted by 4 per cent, increasing its density from 2.6 to 2.7. The normal contraction (or expansion) was thus a joint effect, but contraction predominated. Siliceous material might be, and had been, added to balance the volume changes; as long as the silica were coarse-grained and suitable, and the firing was proper, Dr. Mellor saw no harm in this practice, which had been condemned as fraudulent.

"Grog" was burnt fireclay or ground firebrick added to the fireclay to serve as a skeleton. If the grog were of the same material, the main difference between the grog and the other clay was that the former had been fired twice and the latter once. That difference tended to vanish with subsequent firings; but if the grog had been fired at higher temperatures, or been made of old materials, the life history of a grog could be followed through 40 firings. Great care should be exercised in the grading of the grog and the fireclay; they should not be mixed in any machine which had a grinding action. The refractoriness could be increased by adding shrunk bauxite, zirconia, carborundum, etc.; the addition of these higher refractories had strong and weak points, because refractoriness should not be pushed at the expense of other properties. Coarse-grained textures were little liable to crack on sudden temperature changes (Edwards and Leese, 1902), it was true; but the crushing strength and tenacity were low, and the coarse grains were more easily penetrated by slags.

As regards machine-made *versus* hand-made firebricks, badly made machine bricks were worse than bad hand-made bricks. But the prejudice against the former was partly due to unfair comparison; it was rather the shorter time the clay was allowed to weather and to turn plastic than the machine process which deteriorated the machine product. Pugmills, moreover, were not good mixers; some of the specimens exhibited showed lamination, which favored cracking and probably spalling. Uniformity of mixture was very essential; in dry or semi-dry machine-mixing air films got between the granules.

A satisfactory substitute for the determination of refractoriness was not yet known; chemical analysis could not supply it. The analyst should clearly distinguish between fine-grained fireclays, coarse-grained fireclays, and firebricks. Analysis was needed, of course, also for checking the mixing and blending. In a composite brick (fortified with quartz, bauxite, etc.) the consumer should be told the approximate proportion and character of the binding clay and the fortifying agent. "Trade secrets prevail most in works whose future lies behind them."

Referring to coarse-grained firebricks in particular, Dr. Mellor said that the above-stated rule, that the coarse grain stood sudden temperature changes best, was not without exception in both senses. Magnesia was also unreliable in this respect. Silica bricks were particularly liable to crack, no matter of what grain; in the first fire the fluxing became saturated with silica, the mixture set, and when the set of the grains was afterward disturbed by internal expansion the binding agent was weakened. Precalcination at a high temperature of the silica might mitigate the trouble; this was done; such bricks did not "ring" so clearly when struck together, however. Other things being equal, fine-grained bricks resisted abrasion, fluxes, flue dust, slags, salt vapors, etc., but, of course, acidic bricks were corroded by basic fluxes and *vice versa.* Weak spots were developed by slags into "sallents"; the joints between the bricks were the weakest spots, and ultimately a brick left the setting and floated on the slag. Large slabs, on the other hand, were liable to crack, and where slag attacks were feared, bricks of uniform size,

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close texture and small joints should be used. When bricks with open and bricks with close texture were exposed to salt vapors, the latter seemed to be more attacked, becoming covered with a thin film of glaze; but the vapors really penetrated more deeply into the open texture, and that became apparent after a longer time.

Concluding, Dr. Mellor said that the manufacturer could largely control the texture, and the consumer should consider the conditions in the different parts of the furnace. Near the top, temperatures were not very high, but fluctuated much, and abrasion by impact had to be guarded against; there was also disintegration because the carbon deposited and the gases reacted with the iron oxide in the bricks, especially when there were oxide nodules; the bricks should be close, compact and tough. In the mid zone slags and salt fluxes had their play, and temperatures were high. In the hearth and bosh the scouring action was severe; the volume changes in the bricks should be small, but tear and abrasion was not likely. Stove-bricks should have a high thermal capacity, and be able to resist sand-blast effects; as regards the heat capacity, the remarkable rise in the specific heat of firebricks with higher temperature was noteworthy. The specific heat the manufacturer might not be able to control; but he could make the bricks strong against streams of fine dust and chemically resistant.

Dr. H. G. Colman briefly reviewed the work of "The Joint Refractory Materials Committee of the Institution of Gas Engineers and of the Society of British Gas Industries." Their task had been to draw up standard specifications and to conduct research. For the first purpose they had visited a number of typical gas works to determine the actual needs, temperature fluctuations, etc. They had not attempted to lay down any ideal rules, but to fix something likely to be complied with. The specifications dealt with three materials: retort or ordinary firebricks, blocks of less than 80 per cent silica, silica bricks with more than 90 per cent of SiO_2. The retort material presented special difficulties because of the rapid and large temperature fluctuations, the hot retorts being refilled with cold coal. The specifications required that the fine dust should be removed from the grog in the manufacture of retorts; at the same time an open, porous structure was required. Those difficulties were not the worst, however; great mechanical strength was required for the retorts, and in that respect also considerable improvement had been realized. One of the chief subjects studied was the influence of pressure on refractories. The material of a retort setting was generally under pressure and in contact with a reducing material and reducing gases, while the ordinary specification tests were performed in an oxidizing atmosphere under no load; they quite understood that this was not desirable, but no satisfactory method of conducting the tests under actual retort conditions had yet been worked out. Both the load and the reducing effects tended to lower the refractoriness, as Dr. Mellor had pointed out.

Dr. R. Lessing showed a very instructive series of specimens illustrating a method of testing he devised five or six years ago for ascertaining the texture and rational composition of refractory mixtures before firing. It consists of a simple process of elutriation by which the true clay substance of the "green" clay is removed by a gentle current of water and separated from the water by allowing it to settle out on standing. The rate of flow of water is so adjusted that the "grog," and also the heavy and coarse grain residue of the "green" clay, consisting of sand, shale, or carbonaceous substances, are left behind in the elutriating vessel. A very simple form of elutriator, accurate enough for works purposes, consisted of a tall glass cylinder into which the water was passed through a glass tube reaching nearly to the bottom. The cylinder was placed in a bucket into which the clay suspension overflowed, and from which the clear water was siphoned off after settling. For the purpose of the test about 500 grammes of the sample (which might be taken before or after "tempering," or from a moulded body before or after drying) were well soaked in water and washed into the cylinder. The resultant products of clay and residue were dried, and a grading test was then performed on the residue, from which the texture of the body and the ratio of "grog," granular clay, shale and coal could be ascertained.

The specimens exhibited showed that, before the standard specification was adopted, mixtures for gas retorts contained very little grog, which had, moreover, suffered from excessive crushing yielding dust, while the "green" clay serving as binder had largely remained in the form of coarse granules instead of being reduced to fine powder. The change in manufacturing methods by which the grog was crushed and graded separately and the powdered "green" clay mixed with it, were shown by specimens taken after the adoption of the standard specification. For comparison, a sample of a German retort mixture was shown, which was remarkable for its large proportion of grog, viz., 66 per cent, as against about 35 per cent in English retorts, and also for the total absence of clay residue, shale, or coal, indicating that the binding clay had undergone some preliminary purification.

The test has been used successfully for the daily control of manufacturing operations, and was recommended by the author for this purpose, and was, in the absence of a reliable quantitative method for ascertaining the texture and rational composition of refractories, a simple and useful guide. It is only applicable to non-fired materials.

Mr. Albert Cliff contributed a short paper on "The Manufacture of Refractory Materials." British manufacturers, he said, had restricted themselves almost wholly to the output of retorts, blocks, and bricks in fireclay or silica. As regards gas retorts there was still cleavage of opinion concerning hand-made and machine-made retorts; old material that had done service for years should be returned to the seat of manufacture; discoloration by carbon did not matter, partially fused or slagged pieces should be kept out. Makers had so far mostly concerned themselves with acid refractories; but there was much promise in basic and neutral groups, and in the present difficult conditions they were endeavoring to fasten working surfaces of chromite, magnesite, or other materials on ordinary fire or silica bricks, a variation of the approved facing of bricks. Mr. Cliff exhibited samples which he considered encouraging, without giving particulars.

Mr. W. Donald being unable to attend, communicated some suggestions as to the exhibits by the Eglinton Silica Brick Company of magnesite (raw and calcined) from Greece and magnesite bricks. These bricks had chiefly been made in Austria before the war, and when the firm had experimented they had found that the magnesite was too pure, but could be improved by adding iron oxide (8 per cent of Fe_2O_3) to secure binding strength without reducing the refractoriness. They were mainly interested now in linings for basic steel furnaces. America used a magnesite cement for this purpose, rather than dolomite. Over here magnesite bricks were used and lined with 14 inches of dolomite, carefully rammed and fitted in, in layers of 3 inches. This rammed dolomite, however, boiled with the steel, not, Mr. Dougles thought, because the dolomite was bad, but because ferrates of lime were formed (dolomite is the natural double carbonate of magnesia and lime), and the magnesite underneath was destroyed. As the Americans did not mention this point, ferrates of magnesia might not be formed under furnace conditions. With the use of dolomite there was also constant need of fettling and hence loss of heat, but the methods in use in America should be tried here. So far magnesite cement had not answered well. When the metal was poured into the steel furnace from the blast-furnace, the magnesite would not bear the weight of the metal any better than the dolomite did, and it was even more difficult to fettle. Mr. Douglas also referred to the exhibits of chrome (ore, cement, brick), and to the suggestions they had made to the Iron and Steel Institute that standards for refractories should be set up.

Mr. Ezer Griffiths, M.Sc., of the National Physical Laboratory, contributed a paper on "The Thermal Conductivity of Materials Employed in Furnace Construction." He gave an example of the importance of good lagging in his introduction. A muffle furnace heated by a Méker gas burner reached 1,300 or 1,400 deg. Cent. in 4 hours; when the outer surface had been covered with a 2-inch layer of magnesia-asbestos, that temperature was attained in less than two hours. As regards furnace construction, he said, one had to distinguish between (1) highly-refractory materials of great mechanical strength and chemical resistivity, and (2) materials wanted as backing to the refractory lining; these latter materials should have low thermal conductivity. In determining the conductivity, which varied greatly with the temperature, comparison should be made at various temperatures and, if possible, with specimens of the size in which they had been manufactured. Reviewing the literature on the subject, he referred first to Wologdin, who found that silica bricks burnt at 1,300 deg. Cent. had a conductivity 50 per cent greater than those burnt at 1,050 deg. Cent.; that there was an increase in thermal conductivity with rising temperature for all materials excepting chromite, which seemed to have a constant conductivity; that the conductivities of carborundum (87 per cent of SiC, 12 of SiO_2) and of graphite bricks (48 per cent of C, 30 of SiO_2) was four or six times greater than that of firebricks. Experimenting on similar lines, Dougill, Hodsman and Cobb[1] had observed that the conductivity of magnesia decreased at higher temperatures, contrary to other observations. Boyd Dudley (American Electrochemical Society, volume xxvii, 1915) had built up a wall of bricks, 3 inches by 4½ inches, heated it on one side, and drilled holes into the bricks, to insert thermo-couples, at right angles to the hot surface. This was a mistake; for Nusselt[2] had shown that when the wires were parallel or perpendicular to the isothermal planes, the temperatures might differ owing to conduction, by 40 deg. Cent. with a brick at 100 deg. Cent. Clement and Egy (University of Illinois, 1909) had applied the specimens in the form of hollow cylinders with longitudinal holes for the thermo-couples; that method was sound, but the specimens had to have the special form (cylindrical), and the radical distances were uncertain.

In his own experiments Mr. Griffiths placed the specimen of manufactured size in a tray filled with molten tin or pressed it, for working at temperatures above 450 deg. Cent., against a hot plate of iron. The wires of the thermo-couples were each sheathed with silica, and the whole couple again sheathed in with a silica tube of 5 millimeters diameter; such a couple could be bent at right angles with the wires *in situ*, the bending being convenient when moving the couple in an arc over the slab. The flow calorimeter was provided with a guard ring, and this ring was separated from the calorimeter by a gap of 1 millimeter, stopped with plates of mica set edgeways; such a gap would, Mr. Griffiths thought, have made the Dougill apparatus more perfect. To obtain concordant results the experiments with thick samples of low thermal conductivity should be continued for days. The first experiments were made with diatomaceous bricks, diatoms being the silica shields or skeletons, probably of plant organisms, produced by the chlorophyll reacting with soluble inorganic salts. The heat-insulating property was largely due, apparently, to the minute air cells enclosed by the silica walls. The earth in question contained 92 per cent SiO_2, besides oxides of iron, aluminium, calcium and of the alkali metals. The powdered material was mixed with a little clay, moulded, and fired at 900 deg. Cent.; the resulting porous bricks had a density of 0.64; the bricks had fair compressive strength, but were friable and would not stand abrasion. The thermal conductivity was found to vary between 0.000310 and 0.000461 c.g.s. units (gram-calories per second per cubic centimeter per deg. Cent.) between 105 and 502 deg. Cent., the maximum hot-face temperature being 939 deg. Cent. Still higher values were obtained with other specimens; when the material was deliberately ground, so as to destroy the structure, however, the insulating power was no greater than that of silica sand. Slag wool, the second material tested, was prepared by blowing steam through molten blast-furnace slag; it was essentially a calcium silicate (silica 43, lime 48 per cent) of density 0.24. Made up into compact mats with galvanized wire meshing over each face (interconnected by wires passing through the mat), the mat proved an excellent insulator, which should not be heated for long periods above 750 deg., however; the conductivity ranged from about 0.0002 to 0.000342 for mean temperatures (means between hot and cold face) of from 194 to 476 deg. Cent. As with the diatoms, the curve conductivity/temperature was practically a straight line. The white magnesia (the third material so far tested), as used for steam-pipe covering, was a basic carbonate prepared with about 15 per cent. of asbestos fiber as binding material; it had a low conductivity of 0.00015 at temperatures up to 350 deg. Cent., but underwent decomposition (liberating CO_2) at higher temperature and fell to a powder; in this state its thermal conductivity was by 100 per cent. higher. Worked into a pulp with water this white magnesia could readily be applied to irregular surfaces.

(To be concluded.)

Thermalene, a Substitute for Acetylene

As a substitute for the ordinary form of acetylene gas for welding purposes a new form of the gas termed Thermalene has been introduced. This is generated in closed tin cases or cartridges, which are charged with alternate layers of calcium carbide and of sawdust, the latter being soaked in oil.

[1]See *Engineering*, vol. c., page 120, as to method and results and also other researches.

[2]See *Engineering*, vol. lxxxvii, page 1, January 1, 1909.

Amateur Notes on Grinding a Nine-inch Mirror

Having ground a 6½-inch mirror with success, the writer was anxious to make a perfect job of a larger size. The grinding of the 6½-inch glass gave an insight into the general methods, and the success of the new mirror would depend chiefly on the study of the troubles in figuring the smaller one. The small mirror was reground three times before arriving at a satisfactory result, and in the telescope, it gave excellent views, but the in-and-out focus test showed a slight under correction.

It will be as well to review briefly the various troubles with the smaller mirror, and the remedies.

Grinding Tool.—The 6½-inch glass was purchased as having an excellent figure; but this statement on the part of the seller was incorrect, so it was decided to regrind it.

Having obtained a cast-iron disc, it was turned up to the required radius in a lathe by calculating the versed sines and turning the face in steps of one five hundredth of an inch. The grinding was then started with No. 100 carborundum, and it was found to be a tedious process to work out the steps to a uniform surface. It may here be stated the author had no knowledge of mirror-grinding, and before starting, he obtained a copy of Mr. Benson's book, "The Making of a Speculum," and worked on the details given in it, except that he used "hand work" instead of a machine.

The trouble in grinding with this cast-iron tool seemed to be that the glass wore away ten times faster than the cast iron, and any imperfection in the shape of the tool necessitated an amount of grinding to obtain a good fit. In grinding the larger mirror it was considered preferable to use a tool and grinder of the same material, bearing in mind the fact that two surfaces, when rubbed together in the proper way, tend to give a proper sphere. Therefore, a glass tool was used for the larger mirror and to insure the two pieces of glass being of a uniform texture, they were both cut from the same plate of "patent plate," 1½ inches thick.

This decision turned out well; in fact, by working two or three hours for six days, the large mirror was hollowed out, rough-ground, and fine-ground ready for polishing. This time also included the preparation of the fine grinding powders.

Abrasive Materials.—Carborundum was used in preference to emery as it is a quicker cutting material; proof of this lies in the fact that the former material has entirely replaced emery for grinding purposes in all modern engineering workshops. For roughing out and rough-grinding No. 80 carborundum was used, then Nos. 120, 220, and F.F.F. The finer grades were prepared from F.F.F., and consisted of 30 seconds, 2 minutes, and 7 minutes. These grades were then followed by 7 minute, 20 minute and 60 minute emery, all obtained from one pound of flour emery. This method is preferable to obtaining the grades from the various washings from the grinding.

Further, in order to be free from any grit troubles, each grade of abrasive was separately washed again, a simple procedure, but one well worth the trouble. In fine-grinding a small smear of soap on the tool prevents any sticking, and seems to give a better surface.

Polishing Materials.—As an abrasive washed crocus powder was tried, but it was found to give an inferior polish to rouge, so the latter was used.

The polishing material was held on pitch for the 6½-inch glass, but after reading an article in the "E.M.," the author started with a mixture of resin, beeswax, and turpentine for the larger glass. This material was much slower than pitch, and had the disadvantage that minute pieces would stick to the polisher and raise a small lump. Pitch was therefore substituted for the resin mixture, and carefully graded to the standard "sovereign test" mentioned by Mr. Benson in his book. During the figuring process paper was also tried, but it is very slow and gives a poor polish.

Testing.—The trouble in testing the 6½-inch mirror was to obtain an accurate reading of the zonal test. The accuracy of the readings depends on the size of the illuminating hole; the smaller this is the better, but the smaller the hole the less light. The remedy is to use a bright illuminant and the ordinary lamp-flame as usually suggested is quite useless for good work. Holes between two and three thousandths of an inch in diameter, and illuminated by a four-volt electric bulb, had been used on the 6½-inch glass, but the small hole acts like a photographic lens and throws an image of the filament across the mirror, giving a band of light. The smaller the hole the narrower the band, and with the 6½-inch glass, it was not so difficult to read; but with the 9-inch glass too much of the top and bottom of the mirror was in shade, and to make matters worse the band of light was not always uniform in brightness.

To overcome this difficulty a miniature Bunsen burner was made, and a small piece of incandescent gas mantle suspended in the flame. The burner was one eighth of an inch in diameter, and this and the piece of mantle were enclosed in a ⅛-inch brass tube with light-tight inlet and outlet. It was not a success, as the mantle continually broke away from the support, especially on lighting up.

Acetylene gas with a small burner (as used for cycle tail-lamps) was placed in the same ⅛-inch brass tube, and success was finally obtained by inserting a gasometer in the circuit. This gives an even flame, and a convenient and handy gas supply. The gasometer which gives a supply for thirty minutes was made from two tins with a counterbalance over pulleys. A cycle acetylene generator was coupled to this generator; the water-drip was not used, but the container was partly filled with water, a lump of carbide dropped into this, and the container screwed on soon fills the gasometer, any surplus gas escaping under the bell of the gasometer. This light gives a brilliant illumination of the mirror with a hole measuring 0.0023 inches diameter (measured under a microscope), and consecutive zonal readings are always obtainable.

Figuring.—The nine-inch mirror was fine-ground three times before a satisfactory result was reached, and the following seems to be an important point. The fine-grinding must be carefully done, so as to obtain a polish quickly; otherwise, if the curve is good with a poor polish, the curve is soon lost, and correcting the polisher except for the final touches, is troublesome, and generally ends in a turned-down edge.

The first zonal test after twenty minutes' polishing gave an almost perfect sphere; the same polisher was used for forty minutes, and the result was a hopelessly turned-down edge. Fine-grinding was resorted to again, and the first-zonal test showed a good spherical surface, but the polish was not good enough. The polisher was then trimmed for hyperbola correction to prevent a turned-down edge, but it did not act in the anticipated way, and the result was again a hopelessly turned-down edge. Local application was tried with the ball of the finger and pieces of pitch, but the glass looked like a zebra, so fine-grinding was started again. This time a short stroke was tried, so as to obtain an oblate spheroid, and the first test showed this result was obtained. Zonal readings were taken and plotted on a curve. The following were the readings:

Zone.	Diam. inch.	Correct Turns.	Measured Turns.
1	2.5	0.39	6.0
2	3.5	0.77	3.9
3	4.5	1.28	3.2
4	5.5	1.92	1.9
5	6.5	2.67	0.4
6	7.375	3.44	—2.3
7	8.125	4.16	—

Zones half an inch wide, except 5 and 6, which are three eighths.

The measurements are given in turns of the micrometer head (40 threads per inch), and the correct turns are calculated by the usual formula for a focal length of 79¼ inches. The measurements are adjusted for the fourth zone.

In all cases, after fine-grinding, full polishing was started with an evenly-grooved polisher with grooves one eighth inch wide. In this case the work was continued with the same polisher for another thirty minutes, and a further test taken as follows:

Zone.	Correct Turns.	Measured Turns.
1	0.39	2.0
2	0.77	2.0
3	1.28	1.4
4	1.92	1.9
5	2.67	2.2
6	3.44	3.0
7	4.16	4.0

The result shows a near approach to a parabola, but with a hump in the center. It will be noted that the same polisher which gave an ablate spheroid now cut away the edge, and the explanation may be due to the fact that after a lengthy polishing the edge of the speculum becomes warm from the hands and expands, bringing the edge in closer contact with the pitch. It has been noticed before that on testing immediately after polishing the surface was oblate spheroidal, but that, after half an hour, when the mirror had cooled down, it had a turned-down edge. It was therefore decided, in order to try and keep the curve, to polish for short intervals, and thus obviate this uneven expansion. Polishing was therefore continued at intervals of twenty minutes, and for five minutes at a time only. In this way the curve was kept and the polish gradually improved, until, under the microscope, only a few small pits at the edge could be seen.

The mirror now showed a good curve, but with a high center, and this was worked out with a three-inch polisher; then a pitch ring was used, 1½ inches wide and 5 inches mean diameter, and finally a pitch ring ½ inch wide and 3 inches diameter, the latter for one minute only. The zonal readings finally agreed with the calculated figures within 0.2 of a turn, but it remains to be seen how the mirror behaves in the telescope.

The above notes are drawn up to show how some troubles in speculum work were overcome. Failures are bound to occur in first attempts, and it is only the study of these failures and their causes which enable a good mirror to be turned out. Until a bright flame and small hole are actually tried it is difficult to realize how close consecutive zonal readings agree with each other, as compared with the usual lamp flame and corresponding large holes.—*M. P. G. in the English Mechanic.*

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